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TECHNOLOGY APPLICATIONS TEAM
Applications of Aerospace Technology

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Technical Monitor: Mr. Raymond P. Whitten

Office of Commercial Programs
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
HEADQUARTERS
Washington, DC 20546

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Appendixes

1.0 INTRODUCTION

This report covers the activities of the Research Triangle Institute (RTI) Technology Applications Team for the period 1 October 1986 through 30 September 1987. The work reported herein was supported by the National Aeronautics and Space Administration (NASA) Contract No. NASW-3841. Mr. Raymond P. Whitten, NASA Headquarters, was the technical monitor. The work was performed in the RTI Center for Technology Applications under the direction of Dr. D. J. Rouse. Other participants in the program were Dr. J. N. Brown, Jr., Dr. John Cleland, Mr. Stephen Lehrman, Mr. Lawrence Trachtman, Mr. Robert Wallace, Mr. Daniel Winfield, and Ms. Nancy Court. RTI consultants participating during the reporting period were Mr. Bernard Maggin, Mr. Reed Barnett, Mr. Tom Dixon, Dr. Francesco Ianetti, Mr. William Z. Penland, Jr, and Mr. Aubrey Smith. The Management Consultant Group assisted the RTI Team in the refinement of the Team's outreach strategy with industry.

Highlights of the RTI Applications Team activities over the past quarter are presented in Section 2.0. The Team's progress in fulfilling the requirements of the contract is summarized in Section 3.0. Section 4.0 summarizes the status of the eight add-on tasks. New problem statements prepared by the Team in the reporting period are presented in Section 5.0. The Team's transfer activities for ongoing projects with the NASA Centers are presented in Section 6.0. Travel for the reporting period is described in Section 7.0. Appendix A lists all industry associations, universities, and Federal agencies participating in Team activities during the current contract. The RTI Team staff and consultants and their project responsibilities are listed in Appendix B. Appendix C lists Team projects by Center, and a glossary of terms used in the report is presented in Appendix D.

The authors gratefully acknowledge the contributions of many individuals to the RTI Technology Applications Team program. The time and effort contributed by managers, engineers, and scientists throughout NASA were essential to program success. Most important to the program has been a productive working relationship with the NASA Field Center Technology Utilization (TU) Offices. The RTI Team continues to strive for improved effectiveness as a resource to these offices. Industry managers, technical staff, medical researchers, and clinicians have been cooperative and open in their participation. The RTI Team looks forward to continuing expansion of its interaction with U.S. industry to facilitate the transfer of aerospace technology to the private sector.

2.0 HIGHLIGHTS

2.1 Projects

The RTI Technology Applications Team activities during the reporting period have led to exciting progress in ongoing projects and the initiation of promising new projects, especially in automation and robotics—an area of emphasis by the RTI Team in the past year.

- Fourteen companies participated in a successful flight test of a **stabilized photographic and sensing platform** for law enforcement and search and rescue activities by rotorcraft. The RTI Team's initiation of this project resulted from the add-on task: **Public Service Helicopter Technology Transfer**--Onboard Equipment Needs Assessment and Technology Identification.

- The RTI Team coordinated the development of a project for the **digital hearing aid**. The 3M Corporation has made a commitment for substantial cofunding and participation in the development, evaluation, and marketing of the system.

- In a TU project initiated by the RTI Team, a **Stirling engine** powered vehicle has completed over 1,000 hours and 7,000 miles of operation.

- The RTI Team provided support to Kennedy Space Center (KSC) in a recently completed, successful demonstration of NASA **heat pipe technology** for air conditioning and humidity control at Bob's Candy Company in Athens, GA. An energy savings of over 50 percent was demonstrated. The technology has been transferred to Dinh Corporation for manufacturing and marketing and has been featured in a Cable News Network report.

- A project to apply NASA materials to the process of **continuous casting of steel** continues to make progress, demonstrating substantial potential for enhancing U.S. competitiveness in international steel production.

- A project based on the results of an RTI feasibility study on the development of an **Integrated System for the Management of Wandering Behavior** is currently being funded by four Federal agencies in addition to NASA. RTI assisted NASA in the selection of a manufacturer that has made a commitment to cofund, develop, and market the system.

- In the past year the RTI Team initiated plans for several automation and robotics projects that have the potential for enhancing the competitive position of U.S. manufacturing. These projects include:

  — An Infrared Robotic Controller for the Factory Floor

  — A Generic Flexible Manufacturing Cell Controller

  — An Expert System for Diagnostics of Automation Systems in Textile Factories

  — An Improved Robot Gripper

  — Telerobotics for Undersea and Mining Applications

  — Robot Simulation

  — Water Jet Machining: Nozzle Design

- RTI Team member Dan Winfield organized and chaired an **Advanced Flow Cytometry Workshop** at Los Alamos National Laboratory in June 1987. The purpose of this workshop was to identify common technology requirements for Earth-based and space-based flow cytometry. The workshop was cofunded by NASA Office of Commercial Programs (OCP), NASA Life Sciences, and the American Cancer Society (ACS). An applications engineering project has been established, in parallel with the Space Station Cytometry Project at Johnson Space Center (JSC), to support transfer of technology developments to a system for terrestrial use.

- **A commercial users panel for industrial telerobotics applications** was organized and chaired by RTI Team member Dr. John Cleland at the Workshop on Space Telerobotics held at the Jet Propulsion Laboratory (JPL) in January 1987. Participants included Perry Offshore, Telerobotics, Inc., Ford Motor Company Manufacturing

Development Center, Caterpillar, Inc., Du Pont Company, and IBM Research. In addition, the Electric Power Research Institute (EPRI), U.S. Army Human Engineering Laboratory of Aberdeen Proving Ground, and U.S. Bureau of Mines were represented. The results of the Commercial Users Panel are reported in Proceedings of the Workshop on Space Telerobotics, Vol. 1, JPL Publication 87-13.

- The RTI Team completed a draft document on the **NASA Space Shuttle Thermal Protection System**. This document is the most comprehensive compilation of available information on the materials, test methods, installation procedures, and innovative concepts that came out of the thermal protection system program. The document describes a wide range of potential commercial applications for these developments. The RTI Team believes that this document will serve as a fundamental response to the many inquiries received at the NASA Centers concerning the thermal protection system program and potential commercialization projects.

- As a result of RTI discussions with the **Institute of Textile Technology and KSC**, a project is being initiated to apply NASA expert system technology to the automation of U.S. textile factories.

- RTI developed an integrated program plan coordinating the four electro-optical applications projects directed at developing devices to aid the low-vision population. This program plan was reviewed, along with individual project plans from each Center (Ames Research Center [ARC], JPL, JSC, National Space Technologies Laboratory [NSTL]), at a NASA TU Low-Vision Planning Session at ARC in February 1987.

2.2 Outreach

The RTI Technology Applications Team continued its outreach activities with industry, associations, State/industry technology initiatives, and Federal agencies involved with the development and commercialization of new technology.

- In **industry outreach** to individual companies, the RTI Team presented the NASA TU Program to Ingersol-Rand, Autographic Digitrol, AMP, Inc., AT&T, Die Cast Dies, Superior Die Casting Corporation, Arnold Systems, the Technical Conference of Footwear Industries of America, Crystal Corporation, Kennametal Corporation, Engineering Development Laboratories, Coulter Electronics, Beckman Instruments, Technicon Instruments, Becton Dickinson, High Technology Services, Inc., Lifeline, Inc., Lockheed Engineering and Management Services Company, Surgimedics Corporation, and Digital Systems Corporation.

- Articles on the RTI Team's activities have appeared in the following newspapers, television news shows, and journals: the **Washington Post**, the **Telegram** (Portland, ME), **Cable Network News** (2 segments), **OMNI** (2 articles), and **Health News**.

- RTI coauthored a feature article in the **Society of Manufacturing Engineers' SME News** entitled "NASA and Technology Utilization: Space Age Technology and the Factory Floor." The Society of Manufacturing Engineers has 78,000 members.

- Dr. Robert Burger, the scientific vice-president of the **Semiconductor Research Corporation**, a consortium of U.S. semiconductor manufacturers, has agreed to serve as an advisor to the RTI Team in the development of application projects for the semiconductor industry.

- The RTI Team participated in the **Semiconductor Industry Association/Semiconductor Research Corporation** joint conference on "U.S. Competitiveness—Analysis and Remedies" in September 1987.

- The RTI Team met with the **Institute of Textile Technology (ITT)**, a research organization established by a consortium of textile manufacturers, to discuss NASA technology for factory automation. RTI coordinated subsequent meetings for ITT at KSC and developed plans to initiate a project next year.

- The RTI Team and Dean Glenn, TUO at Johnson Space Center, made a presentation on the NASA TU program to the Board of Directors of a **national venture capital group**, Houston Partners.

- The RTI Team made presentations on the NASA TU Program to national conferences of the **Footwear Industries of America** and the **Prescription Footwear Association**.

- The RTI Team met with the **Health Industry Manufacturer's Association (HIMA)** to discuss the NASA program. Norman Estrin, HIMA's Vice-President for Science and Technology, has agreed to serve as an advisor to the RTI Team in the development of applications projects for the health industry.

- The RTI Team met with the **Clear Lake Economic Development Council** in Texas to facilitate the transfer of NASA technology to Clear Lake industry, focusing initially on the petrochemical industry.

- As part of its activities to transfer NASA technology to needs in rehabilitation, the RTI Team met with staff at **Gallaudet University** (a National school for the deaf), the **United Cerebral Palsy Association**, and the **National Rehabilitation Hospital**.

- The **National Easter Seal Society** invited the RTI Team to serve as a member of their Technical Advisory Board. RTI Team member Larry Trachtman attended an organizational meeting of the Board in Chicago in August.

- The RTI Team has been asked to help several national organizations focus on the applications of technology for our aging population. Dr. Doris Rouse has agreed to serve on the National Forum on Technology and Aging and as an editor for the **International Journal of Technology and Aging**. The RTI Team was asked to participate in a Markle Foundation conference on Electronic Technologies and the Elderly.

- In outreach to **State/industry technology initiatives**, the RTI Team made a presentation to the Director and staff members of the **New Jersey Commission on Science and Technology** in Trenton, NJ. As a result, the Commission is planning RTI Team discussions with several of the industry/university consortia established by the Commission.

- The RTI Team met with personnel at the **National Bureau of Standards** to discuss possible industry applications of NASA-developed technology in the metrology of the Space Shuttle Rocket Motor components.

- The RTI Team has also met with the following **Federal agencies** to develop new projects:

  — Federal Bureau of Investigation

  — Federal Aviation Administration

  — National Institute of Neurological and Communicative Disorders and Stroke

  — National Cancer Institute

  — National Institute on Disability and Rehabilitation Research

  — Veterans Administration

  — Administration on Aging

  — National Institute on Aging

  — National Eye Institute

- RTI has served as a member of the **NASA Code C Outreach Executive Committee**, attending meetings at KSC, JSC, and Marshall Space Flight Center (MSFC)—as well as a meeting of the Marketing Subcommittee in Washington, DC.

2.3 Assistance to NASA Centers and Headquarters

An important component of the RTI Team program is the assistance provided to NASA Centers and Headquarters. As seen in RTI's travel log, Section 7.0, the RTI Team members visit every NASA Center each year and most Centers on several occasions to discuss new and ongoing applications engineering projects. Examples of these activities during the past year are described below.

- RTI established a consultant, Mr. Reed Barnett, in the **Kennedy Space Center** area to assist the Technology Utilization Office at that center in the development and coordination of applications projects.

- As in previous years, RTI Team members attended and participated in complete technology utilization program reviews at NASA Centers. In the past year, the RTI Team participated in reviews at the **Jet Propulsion Laboratory, Marshall Space Flight Center, and Langley Research Center (LaRC)**.

- In response to a request by **Ames Research Center**, the RTI Team supported a consultant, Mr. Tom Dixon, to conduct market assessments for application engineering projects on (1) a Three-Dimensional Auditory Display System and (2) Boron-Containing Organosilane Polymers and Ceramic Materials.

- The RTI Team provided special support to the new Technology Utilization Officer at **Johnson Space Center** by making eight trips to that Center during the year to assist in outreach and applications engineering project development.

- The RTI Team assisted **all the Centers** in preparation of project operating plans for next year. This is an important interaction in assisting the overall planning for applications engineering projects and in setting priorities for commercializing NASA technology.

- In response to a request by the **National Space Technologies Laboratory** and the Mississippi Technology Transfer Center, the RTI Team conducted a market evaluation and prepared a final report for a commercial partner on the development of a hydraulic-powered elevating commode seat for use by the elderly and the physically disabled.

- The RTI Team participated in the NASA High Temperature Superconductivity working group, which met at **Lewis Research Center** (LeRC) in September 1987. The objectives of this meeting were to prepare a program plan, describe NASA applications, and develop a presentation for consideration by NASA Headquarters management for a multi-code program in high-temperature superconductivity.

- The RTI Team met with staff from **NASA Headquarters Code ST** and a contractor, the Egan Group, to provide the OCP assistance in identifying commercial applications of space robotics.

2.4 Linkage

The RTI Team continues to support linkages with other elements of the NASA TU Program with the goal of establishing more efficient and effective transfer mechanisms.

- More than 25 referrals have been made to the Industrial Application Centers (IACs) from inquiries originally directed to the RTI Team.

- **New England Research Applications Center (NERAC) and RTI Team** members have made joint presentations to organizations, including AT&T, on the benefits of information dissemination and active technology transfer.

- The RTI Team has assisted the **Aerospace Research Applications Center (ARAC)** in Indianapolis, IN, with developing a strategy for technology transfer through a "hard" technology program. Following a planning meeting with ARAC Director, Dr. Timothy Janis, the RTI Team prepared a document describing industry requirements for sensor and control system technology.

- In support of the **Pittsburgh IAC**, the RTI Team forwarded an extensive file developed by the Team on the status and requirements of the U.S. machine tool industry as well as the names and addresses of individuals in machine tool associations and companies. The RTI Team also participated with the Pittsburgh IAC in a joint presentation to **AMP, Inc.**, senior management at AMP headquarters.

- **WESRAC** is the designated NASA interface with the Federal Laboratory Consortium (FLC). The RTI Team forwarded three problem statements to WESRAC for distribution to the FLC network.

- The RTI Team visited **COSMIC** in Athens, GA, to discuss collaboration in developing software transfer projects.

- As noted above, the RTI Team has increased its participation with the **Federal Laboratory Consortium (FLC).** The RTI Team attended the Spring 1987 meeting of the FLC in Lexington, KY, and met with many representatives of State and Federal organizations. NASA Headquarters has asked the RTI Team to make a presentation at the Spring 1988 FLC meeting in Washington, DC.

- The RTI Team supported the NASA **Technology Utilization Network System (TUNS)** development project and attended a TUNS Users Working Group meeting at NASA Goddard Space Flight Center (GSFC) in February 1987.

3.0 BASIC CONTRACT STATUS

This section summarizes the status of the deliverables for the basic Technology Applications Team contract (NASW-3841) at Research Triangle Institute. The status reports for the contract add-on tasks are presented in Section 4.0.

The statement of work for the Technology Applications Team specifies the following:

- **30 Problem Statements** should be developed by the Team. The problem statements should seek solutions to well-defined technology requirements in bioengineering and industry.

- **20 Opportunities** for applications engineering projects with NASA Centers should result from these problem statements. An opportunity is developed by the identification of a NASA technology with the potential for meeting the technology requirements described in a problem statement.

- **12 Research and Technology Operating Plans (RTOPs)** should be developed from these opportunities at NASA Centers. An RTOP or project plan for an applications engineering project is submitted to NASA Headquarters for funding consideration.

The Technology Applications Team's results in meeting these contract requirements are summarized in Table 1. Because the statement of work specifies that approximately 50 percent of the Team's effort should be on industry (I) projects and 50 percent on bioengineering (B) or rehabilitation (R) projects, a column indicating the category of each project is included in the table. Problem statements prepared by the Team during the reporting period are presented in Section 5.0. In addition to these new projects initiated this reporting period, the RTI Team continued to assist the NASA field centers in developing and monitoring projects initiated in previous reporting periods. The RTI Team's activities in the coordination of these ongoing projects are described in Section 6.0.

TABLE 1. CONTRACT STATUS—OCTOBER 1986 THROUGH OCTOBER 1987

Problems prepared by Team	Opportunity	RTOP	Category	Center
Hydraulic Control System for Body-Powered Upper Limb Prostheses	Yes	Yes	R	JSC
Infrared Physiological Data Link	Yes	Yes	B-E	JSC
Transparent Coating	Yes		I-M	LaRC
Automobile Emergency Vehicle Alert System			R	
Water Jet Nozzle Design	Yes	Yes	I-A	MSFC
Protective Coatings for Advanced Cutting Materials	Yes	Yes	I-M	LeRC
Generic Flexible Manufacturing Cell Controller	Yes	Yes	I-A	ARC
Expert System for Custom Footwear Fitting Process	Yes		R-A	ARC
High-Performance Single-Phase Heat Transport and Storage Systems	Yes	Yes	I-M	MSFC

(continued)

TABLE 1 (continued)

Problems prepared by Team	Opportunity	RTOP	Category	Center
Intelligent High-Performance Robot Gripper	Yes	Yes	I-A	GSFC
Automated Chromosome Analysis System	Yes	Yes	B	JSC
High-Energy Radiotherapy Imaging	Yes	Yes	B	GSFC
Self-Adjusting Socket for Optimal Fit of Lower-Limb Prostheses			R	
Topographic Measurement for Patient Positioning During Radiation Therapy	Yes	Yes	B	MSFC
In Situ Monitoring of Organic Compounds in Groundwater	Yes		I-E	ARC
Methods to Reduce Porosity in Aluminum Die Castings	Yes	Yes	I-M	LeRC
Contactless Electroplating	Yes		I-E	LeRC

(continued)

TABLE 1 (continued)

Problems prepared by Team	Opportunity	RTOP	Category	Center
Noninvasive Assessment of Tissue Perfusion	Yes	Yes	B	LaRC
Composite Materials Container for Transportation of Explosive Devices	Yes	Yes	I-M	NSTL
Protective Coatings for Aluminum Die Casting Dies	Yes	Yes	I-M	LeRC
Swimming Pool Safety Alarm			I-E	
Slag Pot Cracking Protection	Yes		I-M	LeRC
Laser Solderability of Standard Electronic Module (SEM) Connectors			I-A	
Development, Production, and Marketing of Polyimide Sulfone Materials	Yes	Yes	I-M	LaRC
Linear Power Generation for the Arnold Oscillating Cascade Power System	Yes	Yes	I-E	LeRC, LaRC

(continued)

TABLE 1 (continued)

Problems prepared by Team	Opportunity	RTOP	Category	Center
PROBLEMS REFERRED BY FIELD CENTERS--REQUIRING SIGNIFICANT TEAM ACTIVITY				
Noninvasive Central Venous Pressure Measurement Device	Yes	Yes	B-E	JSC
Ultrasonic Measurement of Pulmonary Muscle Characteristics	Yes	Yes	B	LaRC
High-Temperature Ceramic Polymer and Fiber	Yes	Yes	I-M	ARC
3-Dimensional Auditory System	Yes	Yes	R	ARC
Industrial Computed Tomography/Computer-Aided Design Integration	Yes	Yes	I-A	MSFC

JSC = Johnson Space Center
LaRC = Langley Research Center
MSFC = Marshall Space Flight Center
LeRC = Lewis Research Center
ARC = Ames Research Center
GSFC = Goddard Space Flight Center
NSTL = National Space Technologies Laboratory

R = Rehabilitation
B = Biomedical
E = Electronics

I = Industry
M = Materials
A = Automation

4.0 ADD-ON TASK STATUS

This section presents the status of tasks added to the basic contract NASW-3841. Task 7, Project Screening and Feasibility Assessment, consists of several elements and has been divided into nine subtasks (7-1 through 7-9) for reporting purposes. The following add-on tasks were completed prior to this reporting period:

TASK 1: Development of TU Project Plans and Viewgraphs

TASK 2: Evaluation of the Market for Ocean Color Scanner Data Products in U.S. Commercial Fisheries

TASK 3: Heterodyne Interferometry Data Logging and Display Systems Development

TASK 4: Conduct Workshop on Medical Equipment Requirements for Emergency Helicopters

TASK 5: Collaborative Applications Engineering Project Between the Food and Drug Administration and NASA Centers

TASK 7-3: Biomechanics and Extravehicular Activity Gloves

TASK 7-6: Technology for the Elderly

TASK 7-7: Assessment of Medical Device Safety

The following add-on tasks were active during the reporting period and are discussed in this section:

TASK 6: Potential Commercialization of Fiber-Reinforced Composites Insulation

TASK 7-1: Public Service Helicopter Technology Transfer--Onboard Equipment Needs Assessment and Technology Identification

TASK 7-2: NASA Thermal Protection System Materials

TASK 7-4: Memory Aid

TASK 7-5: Rehabilitation

TASK 7-8: Automation and Robotics

TASK 7-9: Technology and Aging Conferences

TASK 8: Computer-Aided Design/Computer-Aided Manufacture (CAD/CAM) for Custom Orthopedic Shoes

TASK 6: POTENTIAL COMMERCIALIZATION OF FIBER-REINFORCED COMPOSITES INSULATION

Start Date: August 1, 1984
Anticipated Completion: June 1987

Status

This project was completed this year under an effort directed by Dr. Alan Miller at the University of Washington with Dr. Cleland of the RTI Team as contract monitor. The project was redirected following the death of Dr. Jim Mueller, the original principal investigator. The potential commercialization of the fiber-reinforced composites insulation (FRCI) developed by NASA has been studied through identification of (1) properties and economics, (2) potential manufacturers, and (3) potential industrial applications and users. The University of Washington completed tabular and graphical representations and text concerning thermal protection system (TPS) properties and testing and modeling techniques of interest to industry. All results of this effort will be included in the TPS document, which is being completed under Task 7-2. The commercialization prospects for FRCI are discussed in detail in that document.

TASK 7-1: PUBLIC SERVICE HELICOPTER TECHNOLOGY TRANSFER (PSHTT)--ONBOARD EQUIPMENT NEEDS ASSESSMENT AND TECHNOLOGY IDENTIFICATION

Start Date: April 5, 1985
Completion: April 1987

Status

This task has been completed. The objectives of Phase One of this program were to identify, define, and prioritize the technological problems associated with onboard equipment and to identify potential NASA technology transfer opportunities. A project to develop a stabilized photographic/optics sensing platform has resulted. RECON Research, Inc., Bend, OR, and the JPL initiated collaboration on this project with support from NASA Technology Utilization, and initial flight testing has been completed.

Phase One began in earnest with plans for conducting a needs identification workshop involving civilian and military emergency medical service (EMS) professionals, interested government agencies, and industry representatives. This workshop was held in March 1984 and a final report distributed in December 1984.

RTI assumed management of the Onboard Equipment Phase One Projects in January 1985. Needs assessment and technology identification activities were coordinated with and presented to the PSHTT Advisory Group in January and May 1985. Continued discussions with EMS professionals, industry contacts, and government contacts (Department of Defense, Coast Guard, etc.) served to further define the technological problems and to begin a prioritization of the problems. This resulted in a consensus statement report on the priority technology needs. An associated final report on **An Assessment of Public Service Helicopter Technology Development Needs** was completed by RTI, along with an executive summary of this report for distribution by NASA Ames.

TASK 7-2: NASA THERMAL PROTECTION SYSTEM (TPS) MATERIALS

Start Date: April 5, 1985
Completion: December 1987 (Second Phase)

Status

Draft chapters were completed on the TPS document describing the development, pertinent data, and commercial potential associated with NASA Space Shuttle TPS materials. The drafts were circulated for review. Review comments were received from most reviewers and incorporated. Chapters 1, 2, 3, and 4 are completed. The final version of the report will be reviewed for publication by Code C at NASA Headquarters, by the JSC TU Officer, and by JSC, ARC, LaRC, LeRC, university, and industry TPS experts. The document will be submitted to NASA Headquarters in December 1987. University of Washington information from Task 6 is being incorporated.

TASK 7-4: MEMORY AID

Start Date: April 5, 1985
Completion: September 1987

Status

The Memory Aid feasibility study is an interagency project supported by the Administration on Aging (AoA), the Veterans' Administration (VA), the National Institute of Aging (NIA), the National Institute of Disability and Rehabilitation Research (NIDRR), and NASA. A panel of experts on memory impairment and the aging population, as identified by the agencies, met on May 14, 1985. The result of that meeting was an agreement that the feasibility study should address the development of a memory aid device for wandering behavior in older persons. Since that time, RTI has accomplished the following subtasks of the study: (1) prepare a state-of-the-art review on the management of wandering behavior in the elderly; (2) discuss the problem area with the expert advisory panel, physicians, health care administrators, and consultants; (3) prepare a straw man design for a conceptual wandering notification system; (4) evaluate the conceptual design through focus group presentations and individual caregiver interviews; (5) promote interest in device development among manufacturers of similar products and those companies with applicable technologies; (6) prepare problem statements to identify available NASA technologies; and (7) assess the factors needed for successful marketing of the device. In addition, a project plan, including a milestone and budget chart for phase A engineering design and phase B prototype development, has been developed. The final report was completed and is available for distribution.

Technologies for the Wandering Notification device have been identified at JSC. RTI provided support to personnel from JSC in the preparation of a project plan, statement of work, and request for proposals (RFP) for selection of the collaborating manufacturer. The RFP was issued by JSC in May 1987.

Five companies submitted proposals in June 1987. Doris Rouse participated as an advisor in the Source Evaluation Committee meetings at JSC in July and August 1987. Cortrex Electronics of San Bernardino, CA, was selected as the contractor. Completion of Phase A, Engineering Design, is expected in March 1987.

TASK 7-5: REHABILITATION

Start Date: October 1, 1986
Completion: March 1988

Status

The RTI Team is being supported by NASA Headquarters and the NIDRR to specify functional requirements for adapting commercially available cooling garment technology for use by high-level spinal cord injured persons. Quadriplegics are unable to perspire below the level of injury to the spinal cord. Consequently, to avoid overexertion and possible heat stroke, these individuals must limit all activities in even moderately elevated temperatures. This can restrict their job performance, travel, and leisure activities, especially in spring and summer months.

ILC Dover of Frederica, DE, currently manufactures and markets the Cool Vest product for use by persons working in high-temperature environments. The vest, which traces its origin to liquid cooling garment technology originally developed by ILC for NASA, uses active circulation of water over ice or frozen gel packs for cooling. The vest is portable, cleanable, can be temperature-regulated, and will operate for three continuous hours per battery charge.

The Cool Vest appears to be well-suited to the needs of quadriplegic individuals. Resources will be used to conduct a feasibility study and to specify the adaptive engineering that would be needed to make the Cool Vest, or another commercially available personal cooling device, suitable for use by quadriplegics. For example, modifications may be required to make the garment wheelchair compatible, to reduce high-pressure areas under the vest or buckles, to provide automatic temperature regulation, and to make the garment easy to put on and take off. The results of the Phase O study will be used by a commercial partner as a prospectus for further adaptive engineering design work, leading to prototype development, clinical evaluation, and commercialization.

TASK 7-8: AUTOMATION AND ROBOTICS

Start Date: September 1986
Completion: March 1988

Status

The RTI Technology Applications Team activities in automation and robotics (A&R) were initiated in FY84 when a project was begun to transfer NASA technology in parallel image processing using deformable mirror devices. Next, in response to a request from JSC to Code I, the Applications Team contributed to a chapter on NASA A&R technology transfer in NASA Technology Memorandum 87566 (**Advancing Automation and Robotics Technology for the Space Station and for the U.S. Economy**, March 19, 1985, prepared by the NASA Advanced Technology Advisory Committee [ATAC]). The Team has also met with members of the Automation Technology Branch at LaRC and with robotics/artificial intelligence (AI) experts at ARC, KSC, MSFC, JPL, and JSC. Potential transfers from Centers the Team has promoted include high-speed focal-plane processing for robotic vision, robot end-effector development, range and range-rate detection, ground-based mobile coupling system, robot simulators, scheduling/planning software systems, a dual-arm manipulator system, and factory floor welders/sprayers with attendant controls. The RTI Team supplied a description of TU activities for the fourth progress report by the NASA ATAC. Extensive A&R support activities by the Team were detailed in the FY86 annual report.

During the reporting period, RTI arranged and chaired a Commercial Users Panel (see Table 2) at the JPL telerobotics workshop. This has led to followup activities between Caterpiller, Inc., Perry Offshore, and NASA. It is anticipated that spinoffs will result from these and other related Team-arranged meeings. Followon meetings and telecons with the U.S. Bureau of Mines have also been conducted. It appears that NASA telerobotics expertise may be ideal for undersea and mining applications. Comments of the panel were recorded verbatim and have been summarized by the RTI Team. The summary appeared in the JPL Workshop Proceedings.

The Team participated in the 1987 American Institute of Aeronautics and Astronautics (AIAA) Conference on Automation in Space held in Crystal City, VA, and discussed space mission planning priorities and technology with attendees.

TABLE 2. NASA A&R COMMERCIALIZATION PANEL MEMBERS

Mr. Joseph S. Byrd Savannah River Laboratories-Du Pont	Dr. Joseph Naser Electric Power Research Institute
Mr. Carl Flatau Telerobotics, Inc.	Dr. Samson D. Schmuter Manufacturing Development Center- Ford Motor Company
Dr. David C. Hodge Army Human Engineering Laboratory Aberdeen Proving Ground	Dr. George Schnakenberg U.S. Bureau of Mines
Dr. Ralph Hollis IBM Research	Mr. Kenneth F. Sebok Perry Offshore
Mr. Eugene F. Leach Caterpillar, Inc.	Mr. Ray Gilbert NASA-Office of Commercial Programs
Dr. Larry Leifer Veterans' Administration and Stanford University	Dr. Thomas Walters Technology Utilization - Jet Propulsion Laboratory

The Team also has assisted with the planning and initiation of an expert system transfer between KSC and the Electric Power Research Institute (EPRI). This expert system, called KATE, evolved at KSC for space shuttle launch system monitoring, fault diagnosis, sensor data analysis, and response decisions. This AI software will be modified and eventually tested in nuclear power plant operation simulations.

The Team presented the NASA program to the Institute for Textile Technology (ITT), which indicated considerable interest in NASA support to textile fiber plant automation. RTI arranged meetings between ITT and KSC systems experts and an applications project involving improved plant control is planned for FY88.

Other projects to be initiated in FY88, resulting from RTI Team efforts, include: (1) further development between GSFC and the commercial sector of a NASA-derived parallel jaw robot gripper incorporating force-torque sensing, and (2) development of a generic flexible manufacturing cell controller through efforts by ARC, Crystal Corporation, and the manufacturing community. Other A&R projects are listed in Table 1.

The Team will accelerate activity under the final phase of this task in FY88. Preliminary contacts have been established with such robotics leaders as Cincinnati Milicron and Westinghouse and will be pursued. Possible NASA automation technology applications have been identified for remotely piloted vehicles and remote control of cranes manipulating delicate equipment.

TASK 7-9: TECHNOLOGY AND AGING CONFERENCES

Start Date: October 15, 1985
Anticipated Completion: September 1987

Status

This task supports the Technology and Aging Work Group, which consists of representatives from NASA, NIA, NIDRR, AoA, and VA. The Interagency Work Group (IAWG) selected low vision and aging as the topic for the first conference.

RTI developed a proposed plan for the conference and reviewed this plan with the IAWG in December 1985. RTI enlisted the consultation of Dr. Eleanor Faye, Dr. Bruce Blasch, and Dr. Constance Atwell in planning for the workshop. This planning group recommended the following four topics for the individual working groups (subsequently approved by the IAWG):

- Reading aids
- Aids for other near tasks (except reading)
- Visual discrimination under conditions of low illumination
- Visual requirements for spatial orientation.

The workshop was held June 9-11, 1986, at the State Plaza in Washington, DC. Seven background papers were presented at the workshop, including one by RTI. The workshop was chaired by Dr. Arthur Jampolsky, and the four working groups were led by Dr. David Guyton, Dr. William Graves, Dr. Constance Atwell, and Dr. Denis Pelli. Eight priority opportunities for technology solutions to problems in this field were identified:

1. Improved telescope
2. Electro-optical image processing technology

3. Simulators for training
4. Low-cost, nonintrusive eyetracker
5. Portable electronic navigation aid
6. New illumination devices
7. Valid vision assessment device
8. Optical character recognition device.

The report on the workshop proceedings has been completed and distributed to the participants and the supporting agencies. In a September 11, 1986, IAWG meeting, the workshop results were reviewed, and RTI was asked to provide additional supporting information for five areas—items 1, 2, 4, 6, and 7 above. This followup report was presented to the IAWG in October 1986. The group elected not to pursue electro-optical image processing or eyetracking technologies, but to continue to evaluate possible opportunities leading to improved telescopes, illumination devices, or vision assessment devices. A problem statement for a low-vision telescope was prepared and submitted to NASA as well as to the Federal Laboratory Consortium.

A review of the five topic areas and of the four NASA electro-optical low vision aid projects was provided to the Interagency Work Group. It was recommended that the Workshop Report be more widely distributed and that RTI keep the IAWG informed of progress of the four NASA projects for consideration of funding at a future date.

TASK 8: COMPUTER-AIDED DESIGN/COMPUTER-AIDED MANUFACTURE (CAD/CAM) FOR CUSTOM ORTHOPEDIC SHOES

Start Date: September 15, 1986
Anticipated Year One Completion: October 1987
Anticipated Year Two Completion: September 1988

Status

The objective of this add-on task, funded by NIDRR, is to coordinate the implementation of the recommendations from two 1984 workshops on CAD/CAM for Orthopedic Shoes and to identify NASA technology for the CAD/CAM system.

Davis Shoe Therapeutics of San Francisco, a subcontractor to RTI, has produced Volume I of a task analysis and manual on custom shoe therapy. The Volume I task analysis addresses the prescription and custom last production process. The Volume I document is in the final stages of production at RTI with the incorporation of black line illustrations and half-tone photographs. Candidate NASA-developed technologies are being evaluated for application to the CAD/CAM of custom lasts. NASA computer software being evaluated includes the NASA NASCAD CAD/CAM software, NASA Relational Information Management Version 5 database management software, and bar-code software for incorporation into an electronic version of the custom footwear paperwork system. Other candidate NASA technologies include materials (composites) and force transducers (tactile sensing arrays).

RTI Team presentations on this program at national meetings of the Prescription Footwear Association, Footwear Industries of America, and Shoe Tech 86 have been well received.

A recent project development has been the interest shown by artificial intelligence scientists at ARC in developing an expert system that captures th thought processes of the custom shoemaker. As part of the second-year project effort, Davis Shoe Therapeutics will work with RTI to develop the skeletal structure of a custom footwear expert system. A key component in the expert system structure will be a classification and coding system for custom shoes and their constituent elements. This prototype expert system will be outlined in a Volume II project document that covers the fabrication of custom shoes and orthoses.

The second year project effort will primarily address computer-based patient assessment, including electronic patient paperwork and foot shape scanning along with the automatic machining of custom last shapes. RTI will work with specific subcontractors to fabricate prototype fixtures for both foot shape measurement and shoe last carving. Prototype systems for these functions and the electronic paperwork function will be demonstrated as separate system elements at the end of the second-year project effort.

5.0 NEW PROBLEM STATEMENTS

AUTOMATED CHROMOSOME ANALYSIS SYSTEM

RTI Team Personnel: Daniel L. Winfield

Problem

The use of cytogenetic techniques for the analysis of chromosomes from tumor samples has become increasingly important as a means for typing tumors and for monitoring their progress over time. Many cancer chemotherapy protocols call for multiple analyses over the course of treatment of a particular disease. The drawbacks to using cytogenetics as an analytical tool are the high cost and the intense labor requirement. Currently, all of the preparation and analysis is performed manually. Thus, the technique would benefit from the use of automated systems.

The major need for cancer cytogenetics is for developing an adequate metaphase finder. The frequency of metaphase spreads is very low, often as low as one to two metaphase spreads per microscopic slide. Finding these metaphase spreads is extremely labor-intensive and tedious. The available metaphase finders require an extensive amount of "training" to identify metaphase spreads above the background since the quality of the chromosomes produced from a tumor sample is inferior compared to that from blood or amniotic fluid cells. The development of such a device would be an enormous boon to the field of cancer cytogenetics.

There are two other features that lend themselves to automation. One is the preparation of chromosome samples and the other is the staining prior to analysis. Most chromosome analyses are performed on cells that are actively dividing in culture. Thus, an artificial culture is established. The cells are arrested in the metaphase stage of the cell cycle by using the appropriate drug, then the cells are fixed and finally dropped into a slide where the chromosomes are released. These steps are very labor intensive. For tumor samples, several different types of strategies for culture and fixation may be employed. A programmable system that could handle these different steps and the desired variations would eliminate

the amount of physical labor, the need for a technician's being present at the odd times at which they are being performed, and any manual errors that may result.

The other features suitable for automation involve automated staining of chromosomes and annealing DNA probes to chromosome spread. Chromosome staining is a very routine, albeit labor-intensive procedure. The use of DNA probes represents a new technique for identification of precise regions of chromosomes. These probes are enhanced by binding to fluorescent dyes (or to radio-labeled chemicals), and then are used in conjunction with stains to identify the specific regions of chromosomes to which they bind. Automated staining of slides is currently being used in hematology laboratories for routine analysis of blood cells. These systems may lend themselves to adaptation for study of chromosomes. The advantages to such systems are that, not only will they decrease the amount of labor for sample preparation, but they will also permit several kinds of analyses on a single slide.

NASA Technology

For several years, JSC has been developing the ability to digitize images from the microscope for the purposes of image enhancement, computer analysis, comparison with training sets, storage, transmission, and recall. JSC has chosen analysis of aberrations in human chromosomes as the model system for space flight development because it is known that chromosomes are altered during space flight and that this system can be used as an elegant biological radiation dosimeter.

The approach for developing an automated chromosome analysis system will be to take maximum advantage of emerging technical developments from a very active private industry, integrate these into a system, and make the technical advances and software developments necessary to reduce operator interaction to near zero. The first generation digital chromosome analysis device (Perceptive Systems) was developed jointly by JPL and JSC with NASA funds and is generally accepted by the genetics community as improved technology. JSC is now developing new methods that are needed to make the system compatible with Space Station and that will materially contribute to the ability of ground-based geneticists to perform chromosome analysis. These methods include a cell autolocator, optics autofocus, image autoenhancement, transmission to ground, and high density onboard storage.

The proposed project to develop an automated metaphase finder applicable to cancer cytogenetics calls for collaboration among Perceptive Systems, Inc., the University of Florida, NASA, and the American Cancer Society. Perceptive Systems would provide the machine and the technical expertise in image analysis. NASA may provide additional technical expertise in image analysis. The University of Florida would provide chromosome samples and technical expertise with handling such samples. The cytogenetics laboratory performs 1,500 analyses per year from blood and amniotic fluid cells. The laboratory is currently adding a cancer cytogenetics service to meet the needs of cancer patients who are treated in clinics and on the wards at the University of Florida. Cosponsorship from ACS would assist in gaining wider acceptance for such systems.

Principals

Dr. Gerald Taylor, NASA JSC

Dr. Harry Ostrer, University of Florida

Cost to NASA

Funding requirements for the projects are:

	Funding, 10^3			
	FY88	**FY89**	**FY90**	**FY91**
NASA OCP	50	90	50	--
NASA Life Sciences		110	200	--
American Cancer Society	65	65	65	--
Industry			50	50

Status

Project plans have been submitted to NASA Headquarters and ACS. A feasibility study is planned for FY88 to support preparation of a detailed proposal to NASA Headquarters Code EB.

AUTOMOBILE EMERGENCY VEHICLE ALERT SYSTEM

RTI Team Personnel: Lawrence H. Trachtman

Problem

Researchers from Gallaudet University recently conducted focus groups among deaf and hard-of-hearing persons nationwide to identify significant needs for new sensory devices. A device to indicate the proximity of oncoming emergency vehicles while driving was mentioned as a need in every focus group. There are close to one million persons who cannot hear more than words shouted in an ear and who could possibly benefit from this device. Perhaps as important is the fact that the use of this device would not be limited to the clinically hearing impaired; hearing drivers are functionally hearing impaired when the windows are up and the stereo or air conditioning is on.

The National Highway Safety Administration estimates that up to 30,000 emergency vehicles are involved in accidents each year. The number of accidents due to failure of a driver to hear an approaching emergency vehicle is not known. However, as brought out in the Gallaudet focus groups, the fear of accidents with emergency vehicles is high among hearing impaired persons. It is equally likely that hearing drivers and drivers of emergency vehicles have apprehension regarding potential accidents. The benefits of implementing an emergency vehicle alert system would include increased protection of automobile drivers, emergency vehicle drivers, and passengers; improved response time of emergency vehicles; and a lowered accident rate involving emergency vehicles with an associated reduction in operating and insurance costs.

Acceptance, promotion, and standardization will be critical to the successful operation of an automobile emergency vehicle alert system. Drivers of both cars and emergency vehicles will need to accept the system and show a willingness to use it. Factors to help increase user acceptance could include integration with existing car equipment, demonstrated improved safety, and a possible reduction in insurance rates. (For example, a smoke detector in the house can lower the premium for homeowners insurance.) Gallaudet will begin pursuing the promotion and regulation aspects of the problem

among public sector organizations, private industry and associations, and the Department of Transportation. A well-planned technical approach to the system will help Gallaudet in their efforts to meet the needs expressed by consumers.

Only one product that addresses this problem is known to be commercially available. It is a low-cost electronic device that uses sound detection to activate a visual LED display that alerts the driver to sounds. The LED readout increases in brightness as sound increases. An informal evaluation showed this product to be, for all practical purposes, completely inoperative in a real-world setting. It failed to distinguish a siren that was less than a block away, but was easily set off by bumps, traffic noise, and radios.

NASA Technology

In consultation with emergency communications experts, Gallaudet has identified four technical aspects to be considered in the development of the alerting system. These are system operation, transmission/receiving technique, driver alerting technique, and hardware considerations. In addition, other factors such as cost, reliability, and maintenance will play important roles in the system's success. Each of these factors, as well as important design considerations, are addressed in the following paragraphs.

Perhaps the most important operational consideration is that the system is passive for drivers of both emergency vehicles and cars. Any additional actions required by the drivers (especially of the car) will reduce the acceptance of the system and increase the likelihood of it not being operational at a critical time. Other operating factors to address in the development process include whether to provide a way to turn the system off, when the warning system should be activated (i.e., by a siren, flasher, or both), and the required distance and directional ranges of the system.

Three possible approaches for transmitting and receiving a warning signal from the emergency vehicle are radio frequency (RF), sound, and light. RF signal transmission could include the use of public radio bands (AM or FM) together

with existing car radios, microwaves, or radar with appropriate detectors, or possibly a new transmission method. Sound transmission and detection could be based on existing sirens (unfortunately there are no current standards for emergency vehicle sirens, thus making acoustic recognition difficult). Various light detection schemes are available, but may be limited by range, interference, and line-of-sight requirements.

The disabilities/limitations of the car drivers, if any, should be considered when selecting an appropriate alerting technique. Light, vibration, and sound may be appropriate for different potential users. Obviously, light or vibration indicators are needed for deaf or hard-of-hearing drivers. The color (if light is used), intensity, frequency, and location of the alerting signal are other important considerations.

Finally, design considerations for the above three technical aspects should be interrelated to the physical characteristics of the hardware used to implement the system. For example, radios exist in almost all cars and, with appropriate visual indicators for deaf persons, may offer a more practical, if not more technically elegant solution. Also, the requirements for retrofitting systems on older vehicles may be different than those for installing the system on new cars and emergency vehicles. The size, weight, and signal transmission/receiving characteristics should be considered as to the placement of the equipment on the emergency vehicle and in the car, and for alerting the driver.

Aside from the technical challenges discussed above, cost, without question, will be a major factor in the system's acceptance. While a higher cost for the component located in the emergency vehicle will be acceptable (perhaps between $200 and $500), the cost of the automobile component will have to be low ($50 or less). Finally, as with any technical innovation, reliability and maintenance may, in the long run, determine whether the system becomes part of the everyday driving routine.

COMPOSITE MATERIALS CONTAINER FOR TRANSPORTATION OF EXPLOSIVE DEVICES

RTI Team Personnel: Stephen Lehrman

Problem

Law enforcement and military agencies require a method for containing and transporting explosive devices. The steel confinement vessel currently used is too large and heavy to be portable. A need exists for a lightweight container for transportation of explosive materials. Composite materials offer the high material strength-to-weight ratio necessary for this application. The proposed container would be designed to transport an explosive device safely from the discovery site to a safe place for detonation. Alternatively, the composite materials container could sustain a detonation at the discovery site and contain fragments while dissipating the heat and over-pressure.

Public safety agencies in many large metropolitan cities and the military need a mobile system for safely transporting an explosive device from the discovery site to a disposal location. Currently, only a few law enforcement departments have invested in a mobile total confinement vessel. The principal reason is the cost ($40,000).

An open-ended cylindrical pressure vessel mounted vertically on a trailer was designed by the Department of the Navy in the 1970s. This vessel directs uncontained blast and bomb fragments upward. This containment system is unsuitable for use in urban areas because of the danger of damaging high-rise buildings, breaking glass, and injuring civilians.

The Federal Bureau of Investigation (FBI) operates the Hazardous Devices School at the Redstone Arsenal, AL. This school trains and certifies all the public safety explosive technicians in the United States in methods of safe handling of explosive devices. The goal of the school is to prevent technicians from being injured by explosive devices by training them in proper safety procedures.

The FBI has agreed to provide expert advice concerning the specification requirement for the composite materials container. Also, the FBI has agreed to serve as a liaison between NASA and local law enforcement departments and military agencies.

A trailer-mounted total confinement vessel was designed by the Munitions Support Directorate, Picatinny Arsenal, Dover, NJ, and built and tested by the Battelle Memorial Institute in Columbus, OH. The vessel consists of a 3-foot-diameter steel sphere mounted on a trailer. Other diameters are available. The vessel is spherical so that it will withstand explosive forces with minimum wall thickness and will equalize these forces in all directions. The complete assembly weighs approximately 1,200 lb and can be towed by a standard sedan. The three critical components of the steel vessel are the sphere made of two welded hemispheres, the reinforcing ring welded around the door aperture, and the door plate.

NASA Technology

NASA has the technology to design, analyze, and fabricate a lightweight composite materials container for transportation of explosive devices. The container is currently envisioned to consist of two major parts: an outer structural shell and an inner disposable liner. The proposed outer shell would be a carbon fiber composite designed to be a secondary containment for projectile fragments. The proposed inner liner would be layers of honeycomb cell structure, Kevlar, ceramics, and insulation. The inner liner would contain the over-pressure, fragments, and heat by means of plastic deformation of the material.

The preliminary design of the composite materials container would be performed by engineers experienced with the mechanical properties and fabrication methods of composite materials. The preliminary design could then be analyzed using finite element methods such as the PAFAC computer program. Proof-of-concept would be determined by prototype testing.

Principals

David Holmes, FBI

Ernest Burdette, Gulf Coast Breeder Corporation

Status

NSTL has proposed a project to develop the Composite Materials Containers for Transportation of Explosive Devices. An organizational meeting was held at the NSTL station with the FBI on March 26, 1987. On July 9-10, 1987, the NSTL Project Manager, Project Engineer, and Technology Utilization Officer (TUO) met with Major Tom Ward (U.S. Army Hazardous Device School) and Eugene McKannon (MSFC). Major Ward provided information on typical design requirements for the explosive charge capacity of the composite materials container. Mr. McKannan discussed MSFC capabilities to fabricate composite material pressure vessels in the MSFC Productivity Enhancement facility. MSFC did not commit to participate.

On September 18, 1987, the NSTL TUO presented the project plan to Mr. Gerald Hlass, Director, NSTL. Mr. Hlass approved the project plan. A letter was sent to the Director of the FBI Bomb Data Center requesting the FBI's formal participation in the project.

NSTL has arranged for the Gulf Coast Breeder Corporation to be the industrial partner through which this technology will be commercialized. The RTI Technology Applications Team prepared a marketing questionnaire that was included in the September newsletter of the International Association of Bomb Technicians. The results of the questionnaire are forthcoming.

The proposed schedule for this project is as follows:

Phase	TITLE
I	Research and Conceptualization
II	Prototype Design
III	Prototype Fabrication
IV	Testing
V	Reporting

Phase I is almost complete. A project review meeting is tentatively set for December 10 at the FBI Headquarters in Washington, DC.

CONTACTLESS ELECTROPLATING

RTI Team Personnel: John G. Cleland

Problem

A technology is needed to provide cathodic current contact for electroplating continuous copper/copper alloy strips. In electroplating of contact strips to be processed into contacts for circuit boards, etc., gold electroplating of the contact surface is common. Precise control of the gold plating process is important to minimize plating thickness and maintain uniformity. Precise control of this electroplating process could save the electrical contacts manufacturing industry millions of dollars per year.

The system needed must be capable of passing a cathodic current ranging from 0.5 to 35 A with a potential of 0.5 to 9.0 V through a copper/copper alloy strip with a cross-sectional area of 0.0004 in^2 minimum. The system must be capable of passing the above current without drying the strips so that the underplate becomes passive. The product (copper/copper alloy) strip size will vary from 0.25 in. long to 2.5 in. long. The product geometry may vary from flat stock (approximately 0.009 in. thick) to a stamped and formed product with protruding latches or formed cantilever shapes. The current processes use various mechanical techniques that make contact with the strip; however, problems are often encountered with poor contact (arcing), mechanical deformation of the product, and scratching of the product.

The existing strip line equipment is required to plate a wide variety of product geometries in small quantities (e.g., 2 hour duration). Quick changeover is therefore a necessity. The RTI Team originally considered two concepts: (1) a liquid-medium contact and (2) current induction in the metal strip through a magnetic field. If a liquid medium is used to provide the cathodic current contact, it must be easily removed or compatible with subsequent processes into which it is dragged. This liquid is probably limited to deionized water. The medium must also be compatible with existing waste treatment practices or be easily treated.

NASA Technology

Examining NASA technology, the RTI Team has emphasized the possibility of current induction. MSFC, JPL, and Lewis Research Center (LeRC) TU Offices have been contacted. Discussions have been held with Mr. James Burkhart and Mr. Henry Geringer, at LeRC. A description of the problem has been sent to Mr. Geringer, who has considerable experience in induction coil heating and processing. It is desirable first to attempt to assess the energy requirements for an induction process and then to examine current stability that can be maintained with such a process. A study of core loss calculations for magnetic materials was done by James Tryner at LeRC in 1982 and could be of interest. Donald Buckley and T. Spalvins at LeRC have investigated the tribologic properties of ion-plated gold on nickel and iron that could be of significance for touching contacts.

Principals

Mr. Robert Moore, Greensboro, NC
Cliff Lemmons, AMP-Winston Salem, NC
Mr. Brad Oldenburg, Harrisburg, PA
Henry Geringer, and Dan Soltis (TU Officer), LeRC.

Status

Cost to NASA

It is estimated that a feasibility study will be required. Cost sharing by AMP is strongly indicated.

Action

The RTI Team will follow up new contacts at LeRC and solicit responses to the problem statement through other TU Offices at other Centers.

DEVELOPMENT, PRODUCTION, AND MARKETING OF POLYIMIDE SULFONE MATERIALS

RTI Personnel: John G. Cleland

Problem

Thermally stable materials represented by polyimide technology are sought. Recent high-technology emphasis has produced a continuing need for products that will withstand long exposure to high temperatures. The need has become particularly acute for high-temperature composite materials used in electrical and thermal applications, including many items for aerospace, electronics, and defense. High Technology Services, Inc. (HTS), has already utilized polyimides based on LaRC-TPI and LaRC-13 materials developed at NASA Langley Research Center. HTS would like to concentrate on implementing polyimide sulfone technology to develop specific materials for high-temperature applications. Materials include polyimide sulfone amic acid, crystalline polyimide sulfones, blends of polyimide sulfones with other polyimic or polyimide acids, and thermally stable films derived from such materials. HTS seeks precipitation and analysis support from NASA for determining the degree of crystallinity and inherent viscosities.

NASA Technology

The Polymeric Materials Branch at NASA Lewis Research Center has developed and continues to develop innovative polyimide materials. LaRC is also particularly interested in applications for polyimide sulfones.

Principals

Milton L. Evans, President, High Technology Services, Inc.
Dr. Terry St. Clair, Polymeric Materials Branch, LaRC
John Samos, Technology Utilization Office, LaRC

Cost to NASA

Cofunding for a project to develop the polyimide sulfone material and to initiate commercialization is estimated to be $150,000 from NASA Technology Utilization and $150,000 from HTS over a 2-year period.

EXPERT SYSTEM FOR CUSTOM FOOTWEAR FITTING PROCESS

RTI Personnel: Robert Wallace

Problem

Custom shoes and other specialty footwear are a critical need and major expense item for the mobility impaired. Custom footwear fitting is a labor-intensive and uncommon podiatric health care specialty. The expert knowledge of the increasingly rare providers of these services is gradually being lost. A need exists to capture this knowledge in computer-based form and make it available to more practitioners. New computer technologies such as artificial intelligence and interactive compact disks (CD-I) provide a means to capture the expert knowledge of the custom shoemaker in both text and graphic forms.

The Artificial Intelligence Program Group at NASA Ames Research Center has developed many state-of-the-art AI applications and demonstration systems. Among these applications are Expert Systems of the complex mental procedures of various domain-specific experts. Most of these Expert Systems are graphically oriented and have highly developed man/machine interfaces.

The Expert System development techniques of the ARC AI Group can be applied to the custom footwear fitting process. These techniques provide the potential to semiautomate the process of generating a custom last shape and custom shoe design starting from electronic prescription paperwork and a three-dimensional data set of a patient's foot. Such a computer-based expert system could significantly reduce the labor costs of providing custom footwear services.

NASA Technology

The Artificial Intelligence Group under the guidance of Dr. Henry Lum at NASA Ames Research Center has developed expert systems for applications similar to the custom footwear fitting process.

Status

A TU Project Plan for an FY88 new start was submitted for this problem from the NASA ARC TU Office.

GENERIC FLEXIBLE MANUFACTURING CELL CONTROLLER

RTI Personnel: Robert Wallace

Problem

A generic new approach to small-scale flexible manufacturing is required that would allow different manufacturing subsystems such as robots, numerically controlled machine tools, and automated material handling systems to work together in a productive coordinated fashion. This approach to small-scale manufacturing has been called a Flexible Manufacturing Cell Controller approach or architecture. This is a partially automated approach to manufacturing that provides a generic interface system consisting of electronic hardware and communications and control software to integrate existing automation equipment into Flexible Manufacturing Cells. A hardware/software architecture is needed that can be used both with new, intelligent machine tools and robots and with older, less computerized machine tools. This architecture should be amenable to evolution through a series of stages, from operator-centered cell sequencing and control to operator-monitored cell control and finally to unmanned cell control. The functional quality of the man/machine interface between the operator and the cell controller is of critical importance in this manufacturing automation technology need.

NASA Technology

The Artificial Intelligence (AI) Group, under the guidance of Dr. Henry Lum at NASA Ames Research Center, has developed techniques for distributed hierarchical control systems similar to the flexible manufacturing cell controller concept. This distributed hierarchical control scheme is one of several automation and robotics technologies that the NASA Ames AI Group is developing for both Space Station subsystem automation and for commercial payloads such as Space Hab and the Industrial Space Facility.

Principals

The development of the "Generic Manufacturing Cell Controller" will be a joint effort among Ames Research Center, Xtal Corporation of Minneapolis, and Manufacturing Technology Transfer elements of the U.S. Air Force. The ARC project team

under the direction of Dr. Henry Lum will work with Xtal Corporation to implement a complete commercial system over a 3-year period. Xtal Corporation will work with the ARC project team to procure a generation-one testbed hardware and software development system. Once the development system hardware and software suite is in place, the project team will begin subsystem development. Subsystem development will follow from a detailed system functional and performance specification. Upon the completion of hardware/software subsystem developments, the project team will perform system integration. With the final integration of the generation-one system, a series of functional and performance tests will be performed. At the completion of the functional and performance test series, a final phase of system demonstration and commercialization will be carried out.

Status

A TU Project Plan for an FY88 new start has been prepared for this problem and forwarded to NASA Headquarters. Xtal Corporation has continued internal cell controller research and development over the last calendar year and seeks to start joint development work with the NASA Ames AI Group in the very near future. Dr. Henry Lum has indicated that his group has the resources and is ready to work with Xtal to transfer Ames-distributed control technologies to a next-generation Flexible Manufacturing Cell Controller.

HIGH ENERY RADIATION THERAPY IMAGING

RTI Team Personnel: Daniel L. Winfield

Problem

Innovative solutions employing solid-state detectors, ionization chambers, or other applicable technologies, are needed to provide real-time imaging of high-energy radiation therapy beams used in cancer treatment. Successful imaging solutions will be able to provide imaging resolution of 1 mm with a signal-to-noise ratio of 500:1 for radiation beams ranging from 1 MeV to 25 MeV. In addition, powerful image-enhancement algorithms are needed to extract the maximum information from the collected image.

Radiation therapy is an important component in the treatment of many types of cancer. Radiation therapy employs either a cobalt-60 source or a linear accelerator with energy levels ranging from 1 MeV to 25 MeV. Absorption of these high-energy beams is governed by Compton interaction, which depends only on electron density and, in the body, is almost uniform throughout. This yields relatively uniform absorption of the radiation in the tissue within the beam.

Although this uniform absorption is highly desirable for radiation treatment, it makes it extremely difficult to obtain usable images of the radiation beam due to the much-reduced contrast. Conversely, diagnostic X-rays are typically 70 keV and depend on photoelectric interaction, which depends on the object density and the atomic number. Thus, typical absorption ratios between bone and tissue are 16:1.

Typical radiation treatments may consist of 7,500 rads. Certain portions of the body begin to necrose (die) at lower radiation doses (e.g., the spinal cord beings to necrose at 4,500 rads). The objective of the treatment is to maximize the radiation dose to the tumor while minimizing the dose to adjacent healthy tissue. To control the shape of the radiation beam, various portals are constructed based on the tumor location. The total radiation dose may be given in as many as 50 different treatments using as many as 3 different portals. It is very important to be able to replicate the patient's position for each treatment and thus replicate the positioning of the radiation portal. Conventional methods for patient positioning require taking an X-ray film, which is of poor quality due to the above-mentioned reduced contrast. In addition, this requires up to 15 minutes per patient,

increasing the time required for treatment per patient and allowing opportunity for movement by the patient despite various table fixtures that are employed to restrict movement.

What is needed is a method to provide real-time imaging of the radiation therapy beam for real-time verification of the portal positioning. With more accurate positioning both prior to and during the treatment, radiation therapists will be able to use closer tolerances in constructing portals, thus further sparing healthy tissue.

The most likely approach, and one that is currently being pursued, is a long, thin ionization chamber. This chamber consists of two parallel metal plates separated by approximately 2 mm. This gap is filled with iso-octane, and a voltage (typically 6,000 volts) is applied across the metal plates. Initial evaluation has indicated that a signal-to-noise ratio of as much as 2500:1 may be possible with this approach. However, several problems can arise. First, the iso-octane is highly flammable and it may break down in the ionization chamber. Other suitable materials may be available. Candidate materials must have a low atomic number but have high insulating properties. Measured currents with such an ion chamber will typically be in the picoamp range, thus the insulating material must have a dark current of about 10^{-12}. An additional problem with iso-octane is that it tends to diffuse through many materials; thus it becomes difficult to seal the ion chamber without a requirement for refilling. Lexan is currently used for the chamber, and an adequate method of sealing the Lexan chamber has not been found.

The radiation imager must be able to image an area at least 30 by 30 cm, preferably 50 by 50 cm. The signal-to-noise ratio should be at least 500:1, with imaging radiation beams ranging from 1 MeV to 25 MeV. Cross talk between electrodes must be minimized. In addition to the design constraints discussed above, the device needs to be easily implemented in the typical radiation therapy department. Ideally, it would consist solely of a flat plate detector, which is an advantage offered by the ionization chamber. The size, shape, electrical connections, etc., must allow positioning of the imaging detector in a full 360 degree arrangement around the patient's body. It is expected that an end product cost below $50,000 will be acceptable for such a device.

HIGH-PERFORMANCE SINGLE-PHASE HEAT TRANSPORT AND STORAGE SYSTEMS

RTI Personnel: Robert Wallace

Problem

A new, more efficient aerospace heat management and thermal conditioning system utilizing a microencapsulated phase change material-based working medium is needed. The system is targeted at aerospace heat management applications such as those aboard the NASA Space Shuttle and Space Station--e.g., flight experiment subsystems such as materials processing equipment, spacesuit subsystems, and satellite avionics thermal conditioning. The system requires control by an embedded sensor/microcontroller package. A microcontroller is a critical enabling element for "tuning" heat management loops in such systems as cooling garments and avionics packages. A need exists for NASA technology in embedded computer control of these types of compact heat management and thermal conditioning systems.

NASA Technology

NASA expertise and advanced engineering capabilities in aerospace systems fabrication and control can be used to design optimal heat management and thermal conditioning systems for commercial aerospace use. NASA technology for fluid based thermal conditioning and management using closed-loop electronic feedback control can result in commercialization of new heat management products and systems. NASA hardware and systems technology in support of Space Shuttle/Station flight experiment packages can be adapted to provide valuable new capabilities and alternatives to Space Commercialization customers.

Status

A TU Project Plan for an FY88 new start was submitted for this problem from MSFC. NASA Engineer James Owens has met with John Richardson and David Colvin of TRDC to discuss terrestrial applications of the microencapsulated phase change material. Applications to avionics heat management and fluids for cooling garments were singled out as leading candidates for early TU activity. The next step toward a project new start is awaiting a final decision on FY88 funding for TU project new starts at MSFC.

Action

R. Wallace of the RTI Team will assist James Owens of MSFC in drafting an RTOP for a TU FY88 new project start if funding support is received from NASA Headquarters.

HYDRAULIC CONTROL SYSTEM FOR BODY-POWERED UPPER LIMB PROSTHESIS

RTI Team Personnel: Lawrence H. Trachtman

Problem

Current figures show that there are approximately 100,000 upper limb amputees in the United States and that 50 percent of these wear some type of prosthesis. Of the 50,000 persons who wear prostheses, approximately 90 percent use a body-powered device, and only 10 percent use an externally powered device.

The trend toward designing more expensive externally powered (or "bionic") arm prostheses is not clearly supported by a recent survey of 30 upper limb amputees. Their responses indicate that the most important features in order of priority are (1) function, (2) comfort, and (3) appearance. Those surveyed agree that they want a prosthesis that is durable and reliable, and that the device should be comfortable and pleasant appearing, although not necessarily human-looking.

The technology used in body-powered upper limb prostheses has not changed significantly since being developed in the 1950s. Shoulder harnesses and cable (steel or plastic) are still used for operation. Problems with cable prostheses include no active control of wrist function, harness discomfort particularly in the underarm area, and the outside mounting of cable hardware that leads to unattractive designs and excessive wear and tear on clothing.

A hydraulic body-powered upper limb prosthesis offers significant improvements in the three areas mentioned above. Specifically, hydraulic lines could be ported to control multiple actuators, including the wrist and terminal device. The increased efficiency of the hydraulics would help reduce the forces of the harness acting on the body. Also, rerouting the hydraulic lines could result in more comfortable harness designs. Finally, internal packaging of the hydraulic components would allow for softer and more natural external materials for the prosthesis.

Additional benefits of improved body-powered arm prostheses include cost savings over the purchase of externally powered devices; psychosocial benefits to current users resulting from better function, comfort, and appearance; and the conversion of some nonwearers into wearers of upper limb prostheses.

Maurice LeBlanc at the Children's Hospital at Stanford has been supported by the NIDRR to investigate the use of the hydraulic body-powered upper limb prostheses. The wearer uses upper body and shoulder movements to actuate the drive cylinder located in the shoulder harness. This cylinder then acts as a force multiplier to drive fluid through hydraulic lines to control a slave cylinder located on the forearm of the limb. The slave cylinder actuates the terminal device.

The proof-of-concept system demonstrated increased force transmission efficiency over standard cable systems. The efficiency of the hydraulic system was constant at 90 percent through 360 degrees of bend, whereas the efficiency of cable systems varied from 10 percent (steel cable on steel housing) to 81 percent (plastic cable on plastic-lined steel housing).

In addition, the proof-of-concept system was retrofitted to an existing below-elbow prosthesis and was tested with six amputees. They found that the hydraulic control system was smoother, slower, and easier to operate as compared to the standard cable control system.

NASA Technology

Although a prototype system has been developed, technology limitations have slowed this and other attempts at the full-scale implementation of a hydraulic control body-powered prosthesis. Specifically, there have been problems in finding an adequate pump or force multiplier eliminating fluid leakage and in packaging components acceptably. An above-elbow prosthesis must be capable of generating 35 to 40 ft-lb of torque. As described by Mr. LeBlanc, this requires improved pump technology that meets the following specifications.

- Pressure capability up to 1,000 psi
- Less than 1.5 inches in diameter

- Less than 0.5 inches thick
- Minimum 2-to 3-year lifetime
- No leakage
- Low noise.

Rotary vane pumps have been suggested as one possible solution. However, problems with these pumps that must be overcome include leakage, wear, noise, low operating pressures, and lubrication. Also, gear pumps offer a potential solution if size constraints can be met. Solutions to the hydraulic control problem for upper limb prostheses can include, but should not be limited to, these types of force multipliers. In addition, fluid distribution and porting methods should be considered as necessary components of an acceptable solution.

Principals

Mr. Maurice LeBlanc, Children's Hospital at Stanford
Mr. Richa d Bozeman, NASA JSC
Mr. Paul Svejkovsky, NASA JSC

Cost to NASA

Funding requirements for the project are estimated below.

	Funding, 10^3		
	FY88	**FY89**	**FY90**
NASA OCP	10	25	25
NIDRR	40	25	25
Industry			25
Total	50	50	75

Status

Technical expertise has been identified in the Power and Propulsion Division at JSC. Mr. LeBlanc traveled to JSC in May 1987 to further refine the design concept for JSC engineers. Mr. Paul Svejkovsky has built and bench-tested a prototype unit based on these design specifications. The prototype was well received at a Project Review meeting held in September 1987 at the Children's Hospital at Stanford. The next phase calls for further modification to the prototype with bench-testing and preliminary clinical trials to follow. The RTI Team is assisting JSC in preparing a Project Plan for continuation through FY90. Preliminary contact with industry has begun, and other rehabilitation applications of the hydraulic technology being developed for this project are being considered.

INDUSTRIAL COMPUTED TOMOGRAPHY/COMPUTER-AIDED DESIGN INTEGRATION

RTI Personnel: Robert Wallace

Problem

Industrial computed tomography (CT) is a technique whereby multiple X-ray scans are processed to reconstruct the three-dimensio. al (3-D) structure of a manufactured item. Industrial CT is used both for article inspection and reverse engineering. Reverse engineering is the process of recreating a manufactured article that is no longer in production. An accurate 3-D model is a prerequisite to the reverse engineering process. Current industrial reverse engineering techniques are seriously limited by the lack of an interface to commercial CAD systems. Hardware and software technology is needed to integrate industrial CT shape data acquisition techniques to commonly available commercial CAD systems.

NASA Technology

Many current NASA flight hardware systems were designed and engineered prior to the widespread use of computer-aided design technology. To capture the as-built 3-D geometry of these hardware systems, NASA has developed and is developing software tools for interfacing shape data capture techniques with various NASA CAD systems. Additional NASA technology exists in computer software-based reverse engineering techniques. Several Space Station initiatives are developing design knowledge capture software that models 3-D physical objects as logical assemblies of geometric features in addition to representing the objects by numerical 3-D coordinates. NASA expertise in developing custom computer "black boxes" will support the development of a commercially valuable hardware/software translator between industrial CT and CAD.

Status

A TU Project Plan for an FY88 new start was submitted to NASA Headquarters from NASA Marshall Space Flight Center.

Action

R. Wallace of the RTI Team will assist Fred Schramm of MSFC in the new project start if funding support is received from NASA Headquarters.

INFRARED PHYSIOLOGICAL DATA LINK

RTI Team Personnel: Dan Winfield/Larry Trachtman

The Infrared Physiological Data Link (IPDL) is a wireless method of transmitting high fidelity biomedical signals, such as the electromyogram and the electrocardiogram, from a subject to a recorder or monitor. The data link consists of a wearable unit that collects, conditions, and transmits the biomedical signals, and a base unit that receives, filters, and separates the biomedical signals. There is also a communication link from the base unit to the wearable unit for control of power usage in the wearable unit. The unique feature of this data link is the use of infrared radiation as the means of communicating the data to and from the subject. This eliminates the need for the cumbersome wires that restrain the subject's or patient's movements. The use of infrared radiation as opposed to radiofrequency transmission provides for better coverage within a closed environment and a cleaner signal due to the lack of electromagnetic interference that would occur from other equipment in use in the same environment. The flexibility of the Infrared Physiological Data Link will lend itself to use in numerous applications within NASA, as well as in commercial and private enterprises. For example, the UCLA Department of Emergency Medicine is very interested in secure communications with EMS helicopters. Restricted space in the cabin makes wire links quite cumbersome, and intrahelicopter radiotelemetry is precluded by electromagnetic interference from flight electronics. Other centers expressing interest include the University of Utah (intensive care units) and Moss Rehabilitation Hospital (gait analysis).

Principals

Penny Saunders, NASA JSC
Jim Crimmins, Wilton Industries

Cost to NASA

Estimated costs are:

	FY87	FY88	FY89	FY90
NASA	30K	100K	115K	--
Industry	50K	100K	125K	150K
Academia	--	20K	20K	40K

Status

Specifications for the IPDL have been completed and Wilton Industries will provide a prototype unit.

Action

A medical electronics company remains to be identified as a marketing partner. RTI will assist JSC and Wilton Industries in securing this involvement.

IN SITU MONITORING OF ORGANIC COMPOUNDS IN GROUNDWATER

RTI Team Personnel: Stephen Lehrman

Problem

Instrumentation capable of performing real-time in situ monitoring of organic compounds in groundwater is desired. Consideration should be given to detectors for gas chromatographs/mass spectrometers (GC/MS), fiber optic chemical sensors (FOCS), and remote fiber spectroscopy.

The oil industry is required to monitor the diffusion from operating wells of organic compounds such as chloro-organics, benzene, and toluene into the groundwater. The standard procedure is to drill a network of 4- to 6-inch-diameter test wells around the operating well. Water samples are pumped out of the test wells and sent to laboratories for analysis. The analysis, performed by GC/MS, identifies the type and quantity (parts per billion) of organic compounds solvent in the water sample.

The process of sampling the groundwater, shipping the sample to a laboratory, and analyzing the sample may require 3 to 4 days. Iso, handling the groundwater samples sometimes introduces errors into the analysis.

NASA Technology

Langley Research Center has developed a portable X-ray fluorescence spectrometer for monitoring inorganic compounds in water. The instrument has been reviewed by the Environmental Protection Agency (EPA) and will soon be comercialized.

In the past, LaRC, ARC, and JPL have all developed small, portable gas chromatographs and mass spectrometers. At one time, ARC and TRW, Inc., were studying the development of a miniaturized gas chromatograph. More recently, ARC has developed a metastable ionization detector and a new electrometer amplifier system for the gas chromatograph in the Cometary Ice and Dust Experiment.

NASA technology in remote fiber spectroscopy and FOCS is unknown. At least one FOCS system, a laser-pulse/fiber-optic liquid leak detector, has been developed at Kennedy Space Center. Because of EPA interest, fiber optic techniques should be given important consideration.

Principals

Wayne Hamilton, Shell Oil Company, Inc.

Cost to NASA

Shell Oil has indicated they may be willing to cofund the modification of suitable NASA technology to comply with their application. Shell Oil would want a demonstration of the technology prior to committing funds.

Status

JPL has responded to the problem statement and submitted applicable technical support packages for review.

INTELLIGENT HIGH-PERFORMANCE ROBOT GRIPPER

RTI Personnel: Robert Wallace

Problem

Rapid advances are being made in the technologies of robotic vision and tactile sensing. Many highly effective robotic vision technologies are now commercially available. Not readily available are effective tactile sensing arrays or force-torque sensitive fingertips for robots. Among the most promising of the new tactile sensing technologies are short-range ultrasonic ranging systems such as the force-torque sensing technology of Bonneville Scientific. Such new force-torque sensing technologies currently are limited in their commercial potential because of the lack of an adequate robotic and effector geometry upon which to mount the sensor. New ultrasonic based systems (such as the Bonneville Scientific technology) optimally require a parallel jaw robotic end-effector design to achieve maximum levels of performance. Goddard Space Flight Center has recently developed parallel jaw robot end-effectors and other Space Station Telerobotics technologies. A technology need exists whereby developers of robotic force-torque sensors can combine their sensor subsystems with appropriate parallel jaw robotic end effectors to produce a commercially viable product.

Increasingly effective machine vision systems are bringing the day closer when truly flexible robot manipulators will perform sophisticated handling tasks that previously could be performed only by humans. A critical technology needed for both space and terrestrial telerobotics and autonomous robotics is force-torquing sensing. New tactile sensing technologies are now emerging from laboratories that still require a proper vehicle to achieve their potential. In many cases this technology is a proper robotic hand or end-effector technology. In the case of the Bonneville Scientific sensor technology, the proper end-effector geometry is provided by a parallel jaw robot hand design. A more advanced electric motor-driven parallel jaw gripper design is needed to provide a commercially viable packaging of the Bonneville Scientific robotic force-torque sensing technology. The following is a list of some technology constraints and specifications for the needed force-torque sensor/parallel jaw end-effector package sought:

- The parallel jaw fingers should allow easy mounting of force-torque sensor fingertips.
- The parallel jaw end-effector design should support power and data cabling to the local signal processing components of the fingertip sensors.
- The system should be configured to support future enhancements to allow integral measurement of object features using tactile arrays.
- The system should be usable in both autonomous and telerobotic force-torque sensing applications.

NASA Technology

Among current state-of-the-art robot end-effectors are NASA-developed high-performance parallel jaw robot grippers. A split-rail, precision, parallel jaw gripper developed at GSFC provides a hardware foundation for an intelligent, high-performance gripper based on closed-loop tactile feedback control. NASA expertise and advanced engineering capabilities in gripper state sensing and control can be used to optimally configure an intelligent robot end-effector. NASA technology for closed-loop, electronic feedback control can help provide a commercially attractive, self-contained robot gripper package. Such a commercial package will provide valuable new robotic capabilities and alternatives to both industrial and space commercialization customers.

Principals

John Vranish, Goddard Space Flight Center

Status

NASA Goddard has received $100K in FY88 funding to initiate this TU new start. John Vranish is working with Robert Wallace of the RTI Team to prepare a formal TU RTOP. A statement of work will also be prepared for any anticipated competitive solicitation for a cofunded NASA/industry project to transfer the NASA Intelligent High-Performance Robot Gripper Technology.

LASER SOLDERABILITY OF STANDARD ELECTRONIC MODULE (SEM) CONNECTORS

RTI Team Personnel: John G. Cleland

Problem

AT&T's completed multilayer substrate (CMLS) assembly is a thick-film ceramic substrate containing surface-mounted devices. Solder-tinned mounting pads are provided for attaching connector leads and flexor circuits. Laser bonding is the process used for bonding connector leads and flexible printed (flex) circuit leads to the CMLS assemblies used on standard electronic modules (SEMs). Laser bonding is a process whereby two solder-tinned objects are brought into mechanical and electrical contact by reflow and subsequent solidification of the solder. Reflow is effected by a control pulse of laser energy directed into the area to be bonded.

For the edge connectors specified by Bell Laboratories drawing No. G823890, it has been found that during initial laser soldering on the first 20 units, a consistent poor wetting characteristic occurred. AT&T specifications require 95 percent wetting all around the flat portion of the connector lead interface to the solder pad and a substantial fillet at the rear of the lead to the solder pad. In general, the flat portion of the connector lead is only wetting about 60 percent along the length of each side, but is adequate at the rear of the lead. The nonwetting portion of the lead edge often extends across the lead thickness as if contaminated or oxidized. During preliminary pull test analysis, a significant content of voids in the separator solder joints was evident. These problems have details very similar to the typical results of Bright Acid Tin Plating.

NASA Technology

Publications on NASA technology related to soldering have been reviewed through the COMPENDEX, NTIS, and RECON data bases. LeRC has conducted a number of investigations of soldered interconnections related to solar photovoltaic cells development. JPL has also examined optimized soldering techniques for solar cell production.

High quality control and assurance requirements under NASA missions require Mil Specs similar to Bell Laboratory's requirements and emphasize extremely high-quality solder joints. Problem statement distribution will be directed to electronics and photovoltaics engineers in the NASA system.

Principals

Mr. R. S. Turner and Mr. W. F. Morgan (Engineering Manager), AT&T.

Cost to NASA

Undefined at this point.

Status

Literature survey and preliminary calls to NASA experts were completed by the RTI team. Responses to the problem statement are expected.

LINEAR POWER GENERATION FOR THE ARNOLD OSCILLATING CASCADE POWER SYSTEM

RTI Team Personnel: John G. Cleland

Problem

The patented Arnold Oscillating Power System (AOPS) is a revolutionary new approach to low-cost energy absorption and power generation. The technology involves a cascade of airfoils or hydrofoils that oscillate in moving fluid streams—either air or water—harnessing kinetic energy to produce useful work. A dynamically scaled model of the device has undergone testing in the wind mode. Although all conventional rotating wind and water turbines invariably involve bearings, the oscillatory nature of the AOPS makes it possible to use reciprocating pumps and electric generators that may be more reliable and efficient than rotating devices. Rotating machinery loads generated near the blade tips must be carried by the beamlike structure of the turbine blades to the point where the loads are removed at the rotor hub. Structural weight, and therefore cost, of rotors increases rapidly as the radius increases.

For the AOPS, it is reasonable to remove power from many points along the span. What is required for this device is a linear generator or alternator for power takeoff. A prototype generator producing a maximum of 500 W might be sufficient for initial testing. Linear velocity (based on frequency of oscillation in pure plunge) is estimated to be from 20 to 200 ft/s in a stroke not exceeding 1 ft.

NASA Technology

Engineers at NASA Lewis Research Center are working on linear generators and related technology (magnetic heat pumps). It has been preliminarily indicated that LeRC efforts are related to electromagnetic launchers, other aeropropulsion requirements, and possibly the Stirling Engine program.

Principals

Dr. Lee Arnold, Arnold Systems, Inc.
Dr. Peter Halpern, Arnold Systems, Inc.
Mr. Lee Douglas, former General Manager, Boeing-Vertol

Cost to NASA

Cofunding estimates for an initial project are as follows: NASA $80,000; Arnold Systems $50,000.

Status

Arnold Systems first talked with the RTI Team, the LaRC TU Office, and Langley managers in the fields of aerodynamics concerning possible testing of the AOPS in Langley wind tunnels. This is still considered a probable option following model fabrication and preliminary testing. At the same time, Dr. Arnold has been pursuing sources for linear generators. In November he plans to speak with Dr. Mowarty of Case Western Reserve University, who is working as a consultant for LeRC on linear generatc s.

METHODS TO REDUCE POROSITY IN ALUMINUM DIE CASTINGS

RTI Team Personnel: Stephen Lehrman

Problem

Porosity in aluminum die castings prevents solution heat treatment and reduces the machinability of the casting. Solution heat treatment is desirable to improve the mechanical properties of the aluminum casting, and machining is often necessary to finish the product. Porosity also affects the ability to coat and weld aluminum die castings. Vacuum systems installed on die casting machines are a proven method for reducing porosity in the castings. Technology is required to improve the vacuum sealing of the die cavity.

Pressure die casting of aluminum by horizontal cold chamber machines is very economical and permits production of dimensionally precise parts with thin walls and minimal surface roughness. The U.S. automobile industry represents a large market for aluminum castings. In 1982, nearly one-half of the 1.3 billion pounds of aluminum castings produced in the United States was used in automobiles and light trucks. However, the character of the market for aluminum castings is changing in terms of the quality of castings required, the processes, and the alloys being used. Although pressure die casting is currently the preferred method for making most automotive aluminum castings, other metal-casting processes are being tested, including permanent mold, squeeze casting, the Cosworth process, and the "lost foam" process.

In horizontal pressure die casting, aluminum ingots are melted with the use of fluoride fluxes in a furnace. A gravity feed transfers the molten aluminum to a holding furnace from which the molten aluminum is ladled into a shot sleeve. The shot sleeve is only partially filled with molten metal. A plunger injects the molten metal through gates into the closed die cavity. While the metal is flowing into the die cavity, the pressure is intensified to increase the casting density and reduce porosity. The dies open and ejector pins release the casting from the fixed die face.

There are four principal sources of porosity in aluminum die castings:

1. Gases contained in the die cavity when the two die halves open and close
2. Gases contained in the shot sleeve that are injected with the molten metal into the die cavity
3. Inclusions, such as oxide particles, contained in the molten metal
4. Vaporization of the water-based lubricant and die release agent used to coat the die surfaces.

These sources of porosity are exacerbated by the turbulent conditions existing when the molten aluminum is injected into the die cavity. Turbulence promotes mixing of the gases and the molten aluminum.

Porosity has a direct effect on the quality, strength, and machinability of aluminum castings. During the solidification phase of a die casting, gases contained in the die cavity are trapped in the aluminum casting. These voids, augmented by inclusions, result in an inhomogeneous product that is not solution heat treatable. Solution heat treatment causes the gas temperature and pressure to rise and blister the casting surface. Solution heat treatment is desirable because it improves the mechanical properties and ductility of the aluminum castings. Ductility is a major factor in the machinability of the otherwise brittle castings.

NASA Technology

NASA technology is desired to improve the die casting process in many ways. The silicon rubber o-rings used to seal the two halves of the die cavity degrade due to physical abuse and contact with molten aluminum. A metal or refractory matrix gasket that can withstand the temperature, pressure, and contact with molten aluminum would reduce the downtime of the die casting machine. Nextel is a ceramic fiber manufactured by 3M and used in the thermal protection system of the NASA Space Shuttle. Nextel is not attacked by molten aluminum and, therefore, could serve as a protective sleeve for a rubber o-ring. NASA personnel with experience using Nextel in the thermal protection system could design an improved vacuum seal.

The molten metal vacuum valve used to control the purging of gases from the die cavity can be improved. Continuous purging of gases while the molten aluminum is injected into the die cavity is desired. For example, the valve stem packing with Nextel ceramic fiber could improve the longevity of the vacuum valve. Other technology, including improved vacuum valves, is desired.

Mathematical modeling of the molten aluminum injection and solidification process could identify ways to reduce turbulent mixing of the gases. Also, mathematical modeling could improve the location of injection gates and vents so that pockets of trapped gases are eliminated.

Principals

Curtis Pohly, Superior Die Casting Corporation

Status

Stephen Lehrman participated in the Society of Die Casting Engineers October 20th seminar on vacuum die casting. Also participating were representatives of three vacuum systems.

NONINVASIVE ASSESSMENT OF TISSUE PERFUSION

RTI Team Personnel: Lawrence Trachtman

Problem

Close postoperative observation of digit replantation and free flap reconstructive surgeries is necessary to allow for early surgical intervention in the event of vascular occlusion. By observing skin color, temperature, capillary refill, and the relative fullness or emptiness of the part, experienced clinicians can give a subjective assessment of the adequacy of the circulation. The decision to reoperate or to otherwise act to improve blood flow is based on sound clinical judgment.

However, observation following surgery is often delegated to nurses or inexperienced staff, and in medical centers where these types of surgery are not routinely performed, there may be few persons capable of detecting postsurgical complications. One need, therefore, is for an accurate and rapidly responsive method of determining the adequacy of tissue perfusion, primarily by lesser-trained personnel, following reconstructive procedures.

In addition, there are related medical problems that may benefit from the same technology. These include the diagnosis and treatment of peripheral vascular diseases, and evaluation of the effectiveness of hyperbaric oxygen treatment for wound healing. A more objective technique for assessing tissue perfusion, in general, could lead to improved wound healing procedures, fewer surgical treatments for vascular disorders, shorter hospital stays and significant cost savings for patients and insurers.

At present, no technology-based method is routinely used to access skin blood flow following surgical replantation or free flap reconstruction. Temperature measurement has been used because of its apparent simplicity, and thermocouples in particular are the most accurate thermoelectric skin thermometers. Although the relationship between continuous temperature monitoring and microvascular tissue transfer remains mainly qualitative, the literature has shown that the digit or free flap is failing if the temperature falls more than 2 °C below the control, or below 30 °C.

Unfortunately, the measurement of skin temperature is subject to many variables, including the temperature difference found over the body normally, and these may preclude direct thermocouple use as a valid perfusion assessment technique. Specifically, any change in ambient temperature or air currents may affect a sensor or the skin surface, as will changes in thermal conductivity of the skin or the metabolism of underlying tissues. In particular for free flap reconstruction, the warming effect of the underlying tissue has been found to mask vascular occlusions, especially within the short term (under 3 hours). Differential temperature monitoring may be more appropriate for digit replantation where warming is due solely to the circulating blood.

Laser doppler has also been used to measure blood velocity, which is proportional to blood volume. It is noninvasive but not noncontacting. While useful for monitoring flow in arteries entering a free flap, it is not as effective in assessing perfusion throughout the flap area.

NASA Technology

Temperature measurement should not be discarded as an evaluative tool for assessing the viability of microvascular tissue transfers. The direct correlation between blood flow and thermal dissipation is scientifically and physiologically justified. However, an assessment technique that is less affected by the heat of underlying tissue and that is noncontacting and noninvasive may be more suited to perfusion assessment. In addition, to be most effective in the clinical setting, the technology should be developed for use by nursing staff or less experienced clinicians. Design constraints include that it be easy to use; provide clinically useful information; provide for continuous monitoring; and be portable, rugged, and non-movement-sensitive.

Engineers at NASA LaRC have developed a new method for measuring thermal diffusivity in the in-plane directions of thin plates. Originally used for nondestructive evaluation of composite materials and for measuring heat transfer coefficients in wind tunnel tests, the new technology may be applicable to monitoring blood flow in surface tissues.

The technique involves a scanned, pulsed source of heat (or cooling) flux and measurements with a thermal imager of the temperature profile of the sample surface as it cools (or warms). The value of this technique is that the data are a time sequence of thermal images of the sample rather than area-integrated or single-point values of temperature history. In addition, the technique is one-sided, meaning that heating and observation occur on the same side of the sample. Output measurements, therefore, correspond to in-plane heat flow versus the through-sample heat flow of more conventional methods. The technique is noninvasive and noncontacting, and placement of the heating (or cooling) source and observation equipment relative to the sample is not critical for gathering data.

Preliminary tests with a simple model of the peripheral vascular system and with a human arm, with and without blood flow occlusion, have validated the possibility of measuring changes in tissue perfusion. Additional modeling of the peripheral vasculature, as well as controlled tests on human and animal subjects, are needed to establish and validate the correlation between recorded temperature changes over time and actual blood flow. Once these tests are completed, development can begin on a clinically useful perfusion monitoring device.

Principals

Dr. Bruce Klitzman, Duke University Medical Center

Dr. Bill Winfree, NASA LaRC

Cost to NASA

Funding requirements for this project are estimated as follows:

	Funding, 10^3		
	FY88	FY89	FY90
NASA OLP	75	105	10
Other		25	40
Industry			50
Total	75	130	100

Status

Engineers at LaRC have purchased hardware and made necessary upgrades on existing equipment in order to begin controlled tests on animal subjects. Physicians at Duke will evaluate the results of these tests and suggest additional evaluation protocols to establish project feasibility.

NONINVASIVE CENTRAL VENOUS PRESSURE (CVP) MEASUREMENT DEVICE

RTI Team Personnel: Larry Trachtman

Problem

A knowledge of the changes in central venous pressure in humans during space flight will be useful in understanding acute and chronic cardiovascular adjustments to weightlessness. However, quantifying CVP by using an indwelling catheter, while providing high accuracy and temporal resolution, is not likely to be used frequently enough during space flight to provide the data required for operational decisionmaking.

JSC Medical Sciences has developed a CVP monitor that provides a rapid, convenient, and noninvasive method of measuring the central venous pressure of crew members. The device uses the Venous Stop-Flow Pressure technique to estimate CVP. Briefly, a unidirectional doppler flowmeter monitors the jugular venous blood flow while end-expiratory intrathoracic pressure is increased by partially occluding expiration. The intrathoracic pressure that transiently interrupts venous blood flow is taken as an estimate of CVP.

In order to transfer the CVP device to terrestrial applications, as well as to improve it for extended flight use, certain changes based on previous clinical and in-flight evaluations will be needed. These include changes to the packaging, doppler flowmeter subsystem, output signal structure, and R-wave detection subsystem. These changes will simplify the use of the device and increase t. e reliability and quality of the data. The improvements will also make the device more marketable.

NASA Technology

Improvements to the CVP measurement system will be made concurrently over a 2-year period. There are four proposed modifications. The first objective is to repackage the device to make it easier to use. Changes will be made in the size and shape of the enclosure to improve access to input/output (I/O) connectors and to reduce stress on the wiring of internal circuits, thus increasing reliability. The second objective will be to replace the present nondirectional continuous-wave doppler

flowmeter subsystem with a more accurate and reliable bidirectional FM model, without increasing size or weight. The third objective is to add circuitry for frequency-to-voltage conversion to provide suitable quantitative analog output of the blood flow to a separate recording device. The fourth objective is to replace the R-wave detection subsystem. The proposed change will eliminate the awkward operating aspects of the current device and also allow for its operation by a person other than the subject.

The work required to implement these changes will be initiated by the personnel of the Cardiovascular Laboratories of the Space Biomedical Research Institute and is expected to take 2 years to complete. Concurrently, the Technology Applications Team at RTI will help identify a manufacturer to cofund the hardware modifications and to evaluate and commercialize the final product.

Principals

Dr. John Charles, JSC, Houston, TX

Estimated Cost to NASA

	Funding, 10^3	
	FY88	**FY89**
NASA	35	20
Industry	20	40
TOTAL	55	60

Status

JSC has submitted an RTOP for continued project support in FY88.

PROTECTIVE COATINGS FOR ADVANCED CUTTING MATERIALS

RTI Team Personnel: Stephen Lehrman

Problem

The machining of difficult-to-machine metal alloys and composite materials requires the use of tools made with advanced cutting materials. Although tool materials have been developed continuously, they have not always kept pace with the increasing difficulty of machining that has resulted from developments in new work materials. Polished synthetic polycrystalline diamond and polycrystalline cubic boron nitride cutting edges bonded to a carbide substrate have demonstrated excellent wear characteristics. A vapor deposition process is desired for applying these polycrystalline materials or diamondlike carbon films to the substrate so that cutting and tool life is improved.

Coated machine tools are widely used by the metal cutting industry. Layers of titanium carbide, titanium carbo-nitrite, and titanium nitride coatings are applied to a carbide substrate and provide excellent wear resistance for machining of ferrous and nonferrous metals. The coatings are applied by chemical vapor deposition and physical vapor deposition at economical growth rates.

Another class of cutting tools consists of synthetic polycrystalline diamond and polycrystalline cubic boron nitride cutting edges bonded to a strong carbide substrate. The polished synthetic polycrystalline diamond material has a randomly oriented crystalline structure that makes the cutting edge superior in strength to a natural diamond. It provides a sharp cutting edge that remains sharp even when machining nonferrous and abrasive materials such as A390 aluminum, copper alloys, bronze, composites, and glass fiber reinforced plastics. The polycrystalline cubic boron nitride has a high hot hardness and chemical inertness that permits it to machine-harden ferrous and difficult-to-machine high-temperature alloys. Examples of material that may be machined by the polycrystalline cubic boron nitride include tool steels, bearing steels, Inconel 718, Stellite, Incoloy 901, and Waspaloy.

It is desired to replace the bonding of a chip of the polycrystalline diamond or polycrystalline cubic boron nitride by a vapor deposition process. Vapor deposition has the advantage of coating the entire substrate and thus permitting the tool to be indexed.

NASA Technology

Lewis Research Center has developed three methods for depositing diamond-like carbon films on substrates. These processes titled ion beam sputtering, magnetron type deposition, and vacuum arc deposition are documented in the references. The equipment is available for depositing 0.1 μm coatings using the ion beam sputtering method. The magnetron type and vacuum arc deposition processes use an argon ion beam to clean the substrate surface prior to coating deposition. This cleaning is critical to the controlled high rate deposition of the coating. The vacuum arc deposition process is not currently operational. Jet Propulsion Laboratory has used magnetron sputtering to deposit tungsten/rhenium/boron coatings on steel substrate. The magnetron sputtering creates highly adherent, wear-resistant coatings at reasonably high deposition rates.

CVD facilities also exist at Langley Research Center and Marshall Space Flight Center. These facilities have been used primarily for crystal growth of noncarbon films.

Principals

James Heaton, Kennametal, Inc.
Bernard North, Kennametal, Inc.

Status

Kennametal sent twenty cutting tool inserts to Dr. Bruce Banks (LeRC). Dr. Banks applied diamondlike carbon coatings of varying thicknesses to the tool inserts. Eighteen of the tool inserts were returned to Kennametal. LeRC retained two inserts for the purpose of performing their own chemical and physical evaluation.

PROTECTIVE COATINGS FOR ALUMINUM DIE CASTING DIES

RTI Team Personnel: Stephen A. Lehrman

Problem

Die casting is the process by which pressurized molten metal is introduced to a cavity or mold until solidification of the metal is completed. Because solidification occurs in a few seconds, this process has been widely adopted to manufacture large quantities of near net shape parts of nonferrous alloys such as aluminum (Al) and zinc (Zn). The final part geometry is often a fairly intricate design.

Die casting dies are relatively expensive to fabricate and sometimes cost as much or more than the equipment used to operate them. This is particularly true for dies used in aluminum die casting. Therefore, an improvement in die life is most important to this industry.

The material used for aluminum die casting dies is generally H-13, a hot work die steel. In some instances, a higher performance alloy such as Waspalloy has been employed. Typical AISI chemical composition (wt%) for H-13 steel is 0.35 C, 1.0 Si, 5.0 Cr, 1.5 Mo, and 1.0 V, and the remainder iron.

The common type of failure for die casting dies is by heat checking or mudlike cracking due to the thermal-corrosion-fatigue environment of the process. As this heat checking appears on the die surfaces, it begins to leave a corresponding network of fins on the casting that must be removed in subsequent finishing operations. As the number of parts manufactured or cycles per die increases, the extent and depth of the cracking also increases, and a more pronounced network of fins is left on the finished part. When these fins either can no longer be removed economically or interfere with the operation, the die is removed for repair or replacement.

The die is exposed to a cyclic environment of temperature, stress, and corrosion. The thermal history of a die cycle is as follows: Molten aluminum enters the die cavity at a temperature of 1,350 °F (depending on the aluminum alloy), the die surface heats up to 1,100 °F, circulating water in the die cools the die surface to 900 °F as the casting solidifies, the casting is removed,

SELF-ADJUSTING SOCKET FOR OPTIMAL FIT OF LOWER-LIMB PROSTHESES

RTI Team Personnel: Lawrence Trachtman

Problem

The principal function of a lower-limb prosthesis is to provide weight-bearing support during bipedal locomotion, thus substituting for the function of the amputated limb segment. This is achieved by providing load transmission through the stump-socket prosthetic interface. The efficacy of this load transmission function is influenced primarily by the biomedical congruence of the stump-socket interface and secondarily by the structural alignment of the prosthesis.

The critical interface between limb and socket should ideally provide a wide area of total contact that facilitates an equalized distribution of pressure during weight-bearing movements. It is through the interface of limb and socket that the patient obtains most of the sensory information necessary to control the prosthesis. Therefore, an important goal of good prosthetic design and amputee rehabilitation should be to maintain optimal condition at the stump-socket interface.

Gradients of pressure tolerance and efficacy of load transmission across the stump surfaces are determined by the anatomy and mechanical characteristics of the stump. Accordingly, the socket geometry must be so configured that loads are distributed without exceeding the tolerance for pressure at each point of the interface.

With increasing age, amputees requiring prosthetic management have a correspondingly greater likelihood of complicating medical conditions such as peripheral vascular disease. Concomitant medical problems may complicate prosthetic management in the following ways:

1. Skin condition of the stump is frequently poor, leading to poor pressure tolerance and increased vulnerability to tissue breakdown.

2. Stump size frequently fluctuates, with or without changes in geometry. This is often related to varying degrees of peripheral edema (fluid buildup) associated with cardiopulmonary impairment.

With significant changes in stump size and/or geometry, other problems are likely to follow. The patient, not recognizing the problem, may continue to wear the prosthesis and develop significant skin ulceration. When perfusion of the resulting wound is impaired because of arterial insufficiency, healing is extremely slow if it occurs at all. The patient may then become nonambulatory without the ability to use the prosthesis. Alternatively, the patient may abandon use of the prosthesis because of discomfort.

Another possibility is that the prosthesis may be modified and the cycle begun again, typically with the stump undergoing further change. In order to have the socket modified, however, the amputee (who is likely to be elderly) must be able to bring the prosthesis to the prosthetist and be present while the adjustment is made (so that the socket fit can be evaluated after the adjustments have been completed). Transportation for such visits may not be available, and the mobility of the amputee without the prosthesis is severely limited.

These problems underscore the need to develop an adjustable prosthetic socket that will accommodate changes of stump volume and geometry as required.

Current practice in the manufacture of below-knee prostheses results in a permanent outer structure that is rigid and nondeformable, with a socket designed to match a particular shape (geometry) and size (volume) of the residual limb. It is well known, however, that the volume, and to some extent the geometry, of a stump can undergo changes from day to day (in some cases, within the same day). With fluctuations of stump size and shape, a mismatch develops between the stump and the socket into which it must fit, resulting in discomfort and other problems in wearing the prosthesis, together with the risk—particularly great for elderly amputees—of skin maceration and breakdown if the improper fit is not recognized and corrected promptly. The needed correction may require premature replacement of the prosthesis because the degree to which the prosthetic socket can be adjusted to accommodate stump changes is very limited.

Inner socket layers originally made of leather are today made of semicompressible foams (P-Lite, Plastazote) and sometimes viscoelastic foams. However, although these materials deform slightly after initial use, their pressure distribution properties are not optimum nor do they adequately conform over an extended time to the daily changes in stump size and shape.

Currently, there is no available socket design that has the capacity for a rapid online adjustment of the volume and/or geometry of the prosthetic socket without resort to irreversible modification or total refitting and remanufacture of another rigid-socket structure.

NASA Technology

The design and techniques employed should be sufficiently flexible and adaptive to accommodate adjustments involving the following variables:

- Volume and geometrical variation, both circumferential and longitudinal
- Surface density/pressure variation (soft-semisolid-solid)
- Compartmentalized volume-shape-pressure variation
- Independent, or at least partially so, volume/pressure adjustment of each compartment.

In addition, the following design criteria should be considered.

- The prosthesis must withstand the pressure within the socket exerted by vertical load at least 150 percent of body weight (up to 250 lb BW).

- The material must tolerate body heat and sweat.

- The material must not cause toxic effects or skin irritations to humans.

- The total weight of the socket should not exceed 20 percent of the total prosthetic weight, which ranges from 2 to 5 lb for below-knee prostheses and 5 to 10 lb for above-knee prostheses.

- The appearance (cosmesis) must be acceptable.

- The method of attachment of the completed socket to the remainder of the prosthesis should be simple.

The solution should include the capability to perform the adjustments of the prosthetic socket either automatically or with a portable unit, e.g., at the patient's residence. One possible approach is to develop a fluid-filled, compartmentalized inner socket layer. Under manual control, the patient or family member could adjust the socket size and shape by regulating the amount of fluid in different cells in the inner layer. Under passive automatic control, pressure gradients would force the fluid to redistribute itself throughout the cells until an optimal fit was achieved. Other designs or techniques that achieve the same end result should also be considered.

SLAG POT CRACKING PROTECTION

RTI Team Personnel: John G. Cleland

Problem

There is a need to increase the lifetime of slag pots in the steel industry by reducing cracking failures caused by the sticking of steel.

With the advent of continuous steel casting and stricter quality requirements, the U.S. steel industry has been required to provide steel of higher quality than in the past. A method commonly employed to improve the quality of carbon steels is to discard the slag and the layer of molten steel closest to the slag to reduce the amount of impurities present in the final steel product. The mixture of molten steel and slag is dumped into a container known as the "slag pot" and then is discarded outside the plant (see Figure 1). There are two sizes of slag pots: a 1,050-ft^3 slag pot used to top the slag from basic oxygen furnace vessels, and a 600-ft^3 slag pot used to accept the slag left in the steel ladles at the continuous casters or at the teeming stations (teeming is the process of pouring steel into molds to produce ingots).

Since the procedure to produce cleaner steel was implemented, the life of slag pots has decreased drastically from 10 years to 1 year. The explanation given for this difference in life is as follows: Earlier, when only liquid slag was dumped into these pots, the slag adjacent to the walls of each pot solidified and formed a thermally insulating barrier between the remaining molten slag and the walls of the pot. The maximum outside wall temperature measured using infrared thermometry under these conditions was 700 °F.

After the molten slag inside a pot was discarded, the solidified slag, or skull, was debonded from the pot by simply tapping the pot on a steel slab base. The brittle skull would crack free from the wall of the pot, and this material would then be discarded. At this time, the pot was sprayed with a water-base release agent (DACAR-Firr Plast T80L) and then placed back in operation.

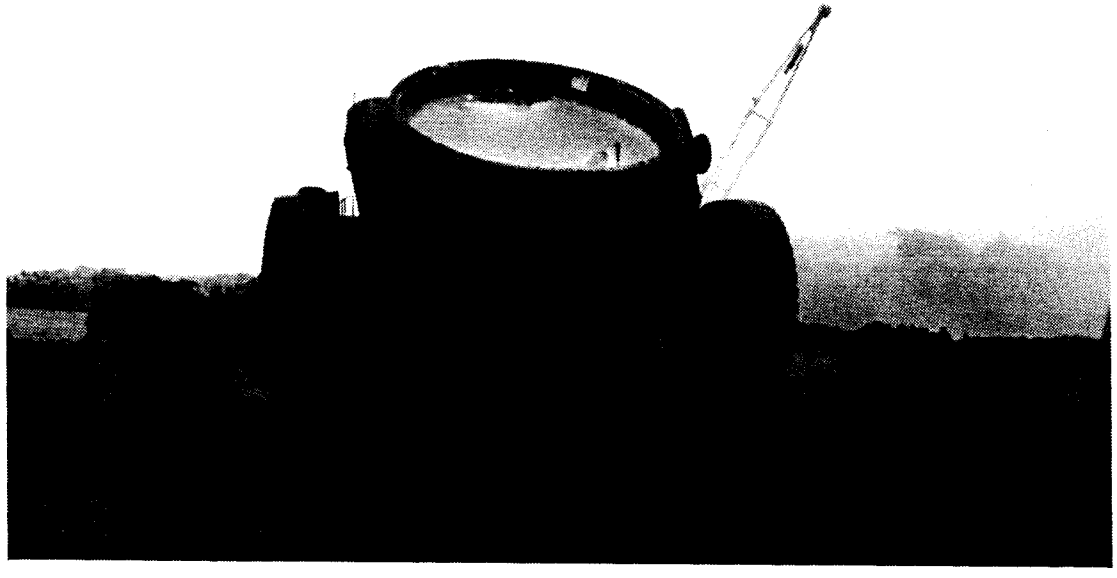


Figure 1. Slag pot in transit to slag pit.

However, when the liquid steel is introduced with the slag, the metal tends to adhere tightly and actually weld to the cast steel pots, particularly in those areas where the molten steel first comes in contact with the pot (see Figure 2). It is difficult to distinguish between molten steel and slag being poured into the pot because at such high temperatures the mixture appears to be a uniform fluid. The spots in the pot where the steel adheres are known as "stickers." They provide a path for the conduction of heat from the molten mixture of steel and slag to the wall of the pot. Outside-wall temperature in these areas increases to a maximum of 1,550 °F. These stickers also cause a state of high thermal stress due to the temperature gradient found aro. nd the perimeter of the pot because some outside areas are at 700 °F and others are at 1,500 °F. Additionally, the stickers result in skulls that cannot be removed by bumping. Repeated attempts by operators to do so, either by dropping the pot against the steel bump plate several times or by using an impact hammer, result in high-impact loads to the slag pot.

Bethlehem Steel Corporation estimates that, based on current operations, it will be necessary at one plant in Chesterton, IN, to replace six small slag pots (600 ft^3) and three large pots (1,050 ft^3) annually at an estimated cost of $650,000. However, the situation is not confined to one plant; but it is an industry-wide problem.

The increased number of slag pots required, combined with Bethlehem Steel Corporation's policy to only buy U.S.-made products has created an additional part supply problem. Most U.S. slag pot manufacturers have gone out of business due to the lower cost of foreign competition.

NASA Technology

Possible alternatives are:

- Use of a different material to manufacture or coat the current slag pot design
- Redesign of the slag pot
- Modification of the pouring and maintenance practices
- Combination of these alternatives.

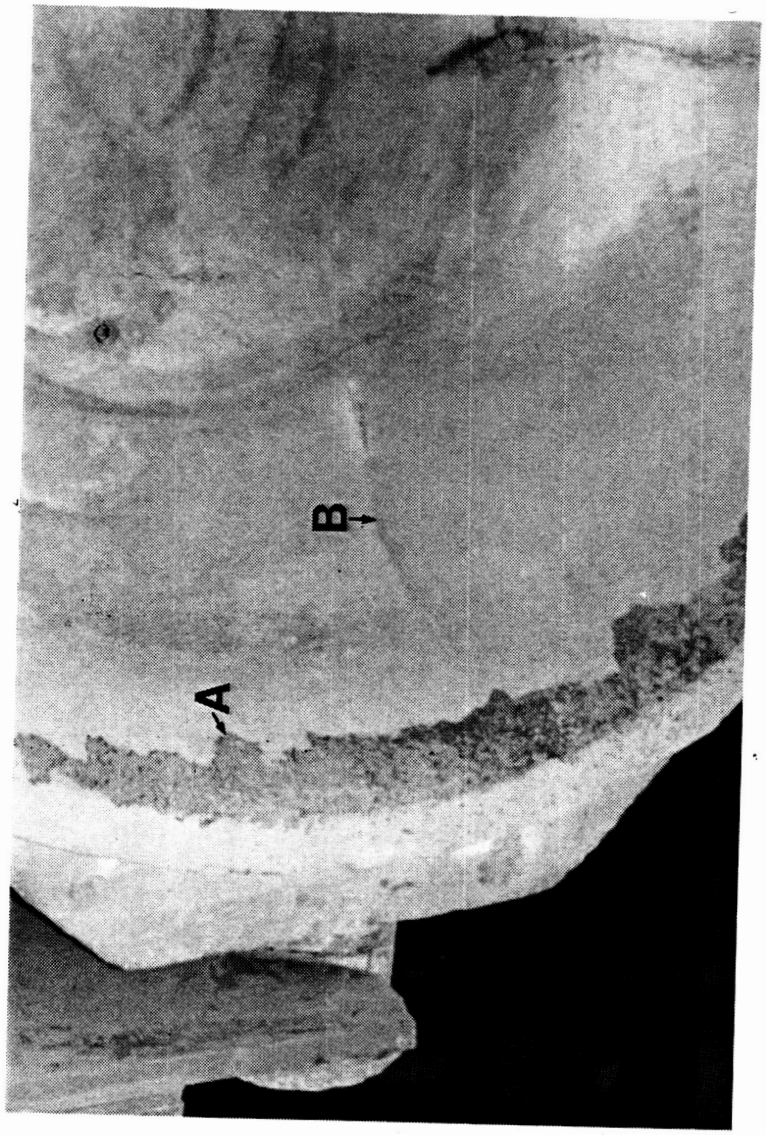


Figure 2. Small slag pot showing "stickers" (A) and cracks (B).

The simplest, most preferred solution would be to coat the inside surface of the slag pot with a material to which steel will not stick or weld and that will survive the aggressive temperature and chemical (alkali) slag environments and maintain integrity under the impact loads required to break the skull. Ideally, it should also provide a thermal insulation barrier. An ideal coating or lining material would have the properties of high-temperature lubricants and thermal barrier coatings and would be ductile in nature. If a coating system is not feasible, then a redesign of the pot needs to be evaluated.

A slag pot design currently employed in other metal melting industries uses a ring with the trunnion and a separate container that fits inside the ring. The semidisposable container is discarded after it exhibits irreparable cracks. For a similar volume slag pot, the outside ring dimensions of the two-part unit must be much larger than those of the currently used body design in order to carry the same load. This is a problem because outside slag pot dimensions are controlled by the very expensive ($\geq$ $1M per unit) mobile equipment (pot haulers) used to transport them.

Another possible solution under this alternative is to make a composite pot with an inner and an outer section. The inner section could be made of a material with a higher temperature capability and toughness than cast steel and the outer section could be made of cast steel, possibly with a thermal barrier between the sections.

A suggested solution for modifying the pouring and maintenance procedures is to coat the internal perimeter of the slag pot with molten slag prior to placing it in operation. A skull would then be formed around this perimeter that would behave as a protective thermal insulation layer. It is unknown at this time how this skull would behave when it is hit by the stream of molten slag and steel.

Principals

The RTI Technology Application Team has discussed this problem with Mr. Richard Mount of Bethlehem Steel Corporation in Chesterton, IN. Other industry-related persons contacted are Mr. Paul Heckman, engineer at the Mackintosh-Hemphill Manufacturing Company in Midland, PA, a slag pot manufacturer; Mr. Tom Penko, technical assistant in foundry coatings for

FOSECO, Foundry Products Division, in Cleveland, OH; Mr. J. Scott Stephenson from Fiber Materials, Incorporated, in Bidderford, MA (ablative coatings); Mr. Jim Maloni of Holman Plating and Manufacturing Company in Dayton, OH (high temperature lubricants); and Dr. F. Iannetti of Design Ideas, in Raleigh, NC. NASA personnel contacted about this problem are Mr. Bill Waters and Mr. Lenny Wesfall (metal coatings), Dr. David Ercegovic (thermal barriers), Dr. Harold Slinei (high-temperature lubricants), all from Lewis Research Center; Mr. Allan Taylor (thermal structures) at Langley Research Center; and Dr. Howard Goldstein (thermal insulation) at Ames Research Center.

Cost to NASA

A small U.S.-made slag pot costs about $65K with a life expectancy of 1 to 1-1/2 years. Thus, the cost of a solution must be balanced between the initial cost increase over the additional years of service. Another major constraint is that the outside dimensions of the slag pots are fixed by the equipment used to transport them. It is expected that Bethlehem Steel Corporation will bear practically all the cost of testing a NASA-related material or design solution.

SWIMMING POOL SAFETY ALARM

RTI Team Personnel: Dan Winfield

Problem

Advanced sensing technologies and/or improved signal-processing algorithms are required to develop a reliable alarm system to help prevent child drownings in residential and commercial swimming pools.

Statistics show that over 500 children under 5 years of age drown in unattended swimming pools each year in the United States. The U.S. Consumer Product Safety Commission (CPSC) has evaluated commercially available swimming pool alarm systems and is now conducting a study to identify various known technologies that can be applied to this problem. The study is focusing directly on pools because pools may or may not be fenced in. Perimeter control systems (mechanical or electronic) may be defeated, or simply not activated, and a system to directly detect a presence in the pool would be valuable. The study will provide recommendations for possibly two or three systems with costs consistent for use in backyard pools as well as larger public pools.

The CPSC evaluation of current systems found that none works reliably, and each has high false positive alarm rates. After very few false positives, typical pool owners will simply disconnect the system. Most current systems consist of one or a combination of two types: acoustic or vertical wave analysis.

Acoustic systems use a low-frequency hydrophone or piezoelectric transducer mounted approximately 36 in. below the surface. Selected spatial frequency information from the acoustic signal can be targeted to indicate the presence of a body (targeted to child size) in the water. This system is fooled by inanimate objects falling into a pool, by pumps turning on or off, and by sounds emanating from outside a pool. No extensive studies have been conducted to determine the precise spectral content of the acoustic signal of a child falling into or playing or swimming in a pool.

The second sensing mechanism is measurement of the amplitude and/or frequency of vertical wave motion in a pool. This may be surface waves or subsurface wave motion. The surface system employs a pendulum arrangement with one end floating on the surface of a pool. The pendulum is part of an electronic circuit so that information on pendulum position, and thus surface wave amplitude, is used to active the alarm. This system is highly prone to errors originating from wind or rain. Subsurface wave systems work on a similar principle at varying depths and have also been found to be unreliable.

NASA Technology

The CPSC is focusing its efforts on systems to detect when a person actually enters a pool as opposed to his or her crossing some intrusion boundary, e.g., a fence. This may employ a sensing mechanism placed in the pool or in proximity to the pool surface or edges. Although system cost will be important, this should not be a driving constraint because even relatively costly systems, if effective and reliable, may prove useful in public settings. Among the technologies considered as possible candidates for the sensor are:

- Acoustic (sound, sonar, pressure waves)
- Optical (photoelectric, video, infrared, ultraviolet, imaging)
- Electromechanical (surface waves)
- Electromagnetic (radiofrequency, microwave)
- Bubble detection.

The sensor must be capable of detecting the entering of or the presence of a body in the water. Ideally, it might be able to discriminate between small children (< 50 lb) and adults, although this is not a necessary constraint. One might also consider the ability to detect a live body from an inanimate object, for example, by detecting a heartbeat or some other parameter. One might even go so far as to consider how to discriminate between a child at play and a drowning victim.

Regardless of the sensing mechanism, the system must be effective and reliable with a minimum of false positives or false negatives. Innovative signal-processing approaches in a microprocessor design will likely be required.

Applicable NASA technologies might include remote physiological monitoring, microwave radar, electromagnetic position sensing, acoustic transducer design, and signal processing/spectral analysis.

Constraints to consider in implementing such an alarm in either residential or public pools include:

- Safety of operation, so as not to endanger swimmers
- Easiness to install, use, and maintain
- Adaptability to a variety of pool shapes and construction methods
- Low cost for homes; cost effectiveness (vs. liability) for public settings.

TOPOGRAPHIC MEASUREMENT FOR PATIENT POSITIONING DURING RADIATION THERAPY

RTI Team Personnel: Daniel Winfield

Source of Problem: Dr. Malecki, Mt. Sinai Medical Center

Technology Requirement

A technique or instrument is required to make topographical measurements of anatomical body parts to assist radiotherapy technicians in positioning a cancer patient's tumor for radiation treatment. Ideally, such data would be interfaced to the treatment equipment (linear accelerator) to reliably reproduce patient positioning relative to the radiation source.

Background

Radiation therapy is an important component in the treatment of many types of cancer. Radiation therapy employs either a cobalt-60 source or a linear accelerator with energy levels ranging from 1 MeV to 25 MeV. The objective of the treatment is to maximize the radiation dose to the tumor while minimizing the dose to adjacent healthy tissue. To control the shape of the radiation beam, various portals are constructed based on the tumor location. It is very important to be able to replicate the patient's position for each treatment and thus replicate the positioning of the radiation portal. Conventional methods for patient positioning require taking an X-ray film, which is of poor quality due to the above-mentioned reduced contrast. In addition, this requires up to 15 minutes per patient, increasing the time required for treatment per patient, as well as allowing opportunity for movement by the patient despite various table fixtures that are employed to restrict movement.

A method is needed to quickly and accurately scan and compute the topography of the region of interest and to use these data for precise positioning of the radiation beam in relation to the body. The system should require minimal preparation, operate in real time, and provide accuracy of $\pm$2mm. It must be able to scan an area of at least 30 cm by 30 cm, preferably 50 cm by 50 cm. The size, shape, and electrical connections must allow positioning in a full 360 degree arrangement around the patient's

body. In addition to the design constraints, the device must be easily implemented in a typical radiation therapy department. The end product should be projected to sell for no more than $50,000.

NASA Technology

MSFC has proposed an adaptation of the Topographical Optical Mapping System to measure other body contours and interface to the linear accelerator control unit. The TOMS consists of a low-power laser-based optical scanner to detect and measure phase information of scattered light from a three-dimensional object. The phase information provides the necessary distance measurements, which are then processed by computer to generate full 3-D mapping.

Principals

Gary Hunt, Marshall Space Flight Center
Dr. Malecki, Mt. Sinai Medical Center

Cost of NASA

Funding requirements for the project are:

	FY88	FY89
NASA	$80,000	$90,000
Industry	$30,000	$30,000

Status

The female breast has been selected as the anatomical region for demonstration of this technique. The TOMS will be adapted to make measurements of this region. Three-dimensional coordinate data will be compared to reference coordinate data to generate drive commands for the control unit of the linear accelerator in use at Mt. Sinai Medical Center.

TRANSPARENT COATINGS

RTI Team Personnel: John G. Cleland

Problem

Requirement 1: Improved transparent coatings are needed for application to instrumentation panels, gauges, and windscreens. Uniforce Company currently uses silicon dioxide-based coatings on both sides of polycarbonate and acrylic panels. An important Uniforce product is digital, color liquid crystal displays (LCDs) whose coatings must accept an epoxy-based silk screening. They purchase these coatings, for example, from the 3-M Company for $\$6/ft^2$ and from Panelgraphics (Vueguard 981) for $\$8/ft^2$.

An examination of these and other siloxane-, polyurethane-, etc., based films (e.g., from Rohm and Haas Company [TUFFAK CM-2], GE [MR-3000], and Quinn [Krystalgard]) produced several findings. Tabor abrasion tests of films typically demonstrated about 2.5 to 3 percent haze increase for 100 cycles. There is less than a 0.5-percent increase for steel wool rotary testing (five revolutions), and abrasion resistance results by ASTM-D-673 show about a 3-percent increase under 1,600 g. Most coatings vendors claim that chemical resistance to visual attack by methylene chloride is improved over polycarbonate substrates by about 240 times and by about 5,000 times for acetone. Most coatings can be applied to a wide range of substrates. Uniforce would like increased abrasion resistance at lower cost.

Requirement 2: Improved transparent shielding is sought for use with machine tools (e.g., lathes, milling machines, and grinders) that throw chips. Current glass screens for operator protection and observation are susceptible to spalling, cracking, and long-term degradation from impacts. Wire mesh is often used on machine tool transparent screens, but obstruction of vision is excessive. The surface should be easily cleanable so that coolants thrown from machine tools can be easily removed without smearing.

NASA Technology

Contacts with JSC and Pittsburgh Plate and Glass have been made, but the potential for NASA technology solutions is still unclear. Space Shuttle or other spacecraft windshields do not seem to provide acceptable solutions. Brief discussions have

been conducted with Dr. Terry St. Clair at LaRC related to some of his recently published work on colorless polyimide-containing, phenoxy-linked diamenes and other optically transparent/colorless polyimides. ARC has done coating work with siloxane followed by plasma treatment. Xenon lamp flash blast treatment was also suggested as a possibility by Dr. St. Clair. This work is possibly being done at ARC. Jim Davis at Uniforce was asked to contact Dr. St. Clair and discuss the problem in detail.

Principals

Mr. James Davis, Uniforce Electronics Corporation
Dr. Terry St. Clair, LaRC
Mr. Tony Bratkovitch, NMTBA

Cost to NASA

No costs are expected related to the initial definition of NASA, Uniforce, and NMTBA interaction. A Technical Exchange Agreement might be arranged between Dr. St. Clair's branch and Uniforce. Development of an applications engineering project could require support funding of $50,000 for feasibility studies, including coating preparation and testing at Uniforce and a NASA Center.

Status

The RTI Team is continuing to explore a suggestion by LeRC for sapphire coating of Lexan.

WATER JET NOZZLE DESIGN

RTI Team Personnel: John G. Cleland

Problem

A growing number of industries are using high-pressure water jet cutting. Materials as diverse as brake linings, printed circuit boards, and advanced aerospace composites as well as cardboard, diapers, and cakes are being cut quickly by needle-thin jets of water forced out of sapphire nozzles at velocities approaching three times the speed of sound (3,000 ft/s). Although water alone will cut most porous materials, high-pressure abrasives in the water jet are used to cut most metals and concrete. Abrasive additives are typically garnet or silicon particles educed into the jet stream upstream of the nozzle. Another application being offered by Kennametal is that of machine tool chip breaking, where a high-pressure water jet is directed against the chip spiraling off a part being machined. This allows close chip size control and, ultimately, machine integration into a completely automated factory. In both cutting and chip breaking, water jet manufacturers have found that considerable losses are indicated in the nozzle region. These nozzles are typically sharp-edged, ranging from 0.003 and 0.018 in. in diameter. Current life expectancy is about 200 hours. Discharge coefficients have not been analyzed adequately, but energy recovery estimates for overall water jet systems are typically less than 10 percent. An optimized nozzle design is needed. One complicating factor is that nozzle orifices, especially for abrasive cutting, wear away to larger diameters, often change shape from circular to oval, and develop grooves. Small increases in efficiency could lead to considerable decreases in operating costs. The market has been growing so rapidly that only minimal research has been conducted.

NASA Technology

Nozzle experts including water jet nozzle designers at LaRC have been identified. JPL also is operating a water jet cutter. Contacts have not yet been established with these technical experts but are planned in the near future.

Principals

Mr. Walter C. Shoup, Autographic Digitrol, Inc.
Mr. Robert Ferguson, Ingersol-Rand Water Jet Cutting System
Mr. Ken Curtis, Ingersol-Rand, Inc.
Mr. James Royal, Kennametal, Inc.

Cost to NASA

Cost to NASA for a project with Ingersol is estimated to be $130K over 2 years. Ingersol has indicated willingness to cost-share in excess of $230K. A feasibility study for Kennametal's Hyperson project might be augmented by funding from NASA Headquarters.

Status

Contacts initially were made with LaRC and JPL. A literature survey was completed. Contact was made with the TU Office at MSFC concerning water jet nozzle design, and RTI was put in touch with appropriate experts in water jet machining and nozzle design at MSFC. MSFC concepts for converging-diverging nozzles and a "flow-screen" annulus approach were considered very appropriate. RTI arranged a conference call between Ingersol-Rand and MSFC, and a tentative agreement has been reached to proceed with a project plan in FY88.

6.0 COORDINATION OF ONGOING PROJECTS

BLADDER VOLUME SENSING

RTI Team Personnel: Dan Winfield

Problem

Loss of the sensation of bladder fullness is a common clinical problem and is often seen in patients suffering from spinal cord injury, stroke, and diabetes mellitus. This problem is often associated with urinary incontinence and can be a very limiting and sometimes embarrassing malady. Clinically, retention can result in urine reflux into the kidneys causing infection, a leading cause of death in patients with spinal cord injury.

In addition, toilet training of many of the severely retarded is never realized because there is no useful means of helping them associate bladder fullness with the appropriate behaviors.

The development of a compact, easy-to-use, bladder fullness sensing device would greatly improve both of these situations. Such a device would work throughout the day and would operate by warning the user when the bladder reaches some preset volume threshold. The device would give the patient the security needed to carry on normal daily activities and, in the case of the retarded client, would provide the paired stimulus necessary to implement a toilet training procedure.

NASA Technology

A device proposed by the LaRC would incorporate state-of-the-art technologies in ultrasonic transducers and signal processing.

Principals

Dr. Albert Cavalier, Association for Retarded Citizens, Arlington, TX
Dr. Beth Mineo, Association for Retarded Citizens, Arlington, TX
Dr. Joseph Heyman, LaRC, Hampton, VA
Dr. Frederich Klein, University of Tennessee, Knoxville, TN
John Companion, LaRC, Hampton, VA

Cost to NASA

The funding required by NASA LaRC is indicated below. The NIDRR awarded a 3-year grant to the Association for Retarded Citizens for $307,127 to develop the bladder volume sensor with NASA. In addition, a $50,000 continuation grant has been provided by NIDRR.

	FY85	FY86	FY87	FY88
NASA	$22,300	$105,000	$55,000	--
NIDRR	$102,000	$118,700	$101,700	$50,000

Commercialization Strategy

The large impact this device will have indicates a ready market for a compact bladder fullness monitor. At the completion of Phase 0, both the RTI Team and the Association for Retarded Citizens staff began discussions with possible manufacturers. Among the interested companies are Johnson and Johnson, C. R. Bard, and Medical Engineering Corp. A notice was placed in Commerce Business Daily requesting expressions of interest from manufacturers. An agreement is in process between the Association and NASA, giving the Association licensing rights for medical applications.

Status

The Association for Retarded Citizens developed a planned protocol for preliminary and field testing of the prototype and its revisions. This protocol, as well as the functional requirements for the device, were reviewed with LaRC staff.

Equipment was completed and Phase 0 studies begun at the Medical College of Virginia in June 1986. Initial results indicate greater variability, particularly among women, than expected. A revised design was completed and further Phase 0 tests conducted from September to December 1986.

The design has been fixed and field tests conducted on NASA-LaRC employee volunteers as well as Association for Retarded Citizens volunteers. Results have proven the validity of the measurement technique and correlation to bladder fullness, but have also revealed transducer fragility and unacceptable power consumption. Battery life has been extended and further work to make the transducer more durable continues. A second unit is scheduled to be delivered to the University of Tennessee in October 1987.

Action

Upon completion of a license agreement between NASA and the Association for Retarded Citizens, RTI will assist in selection of a manufacturer and in developing further plans, including testing with other populations.

CALCANEAL/METATARSAL FAT PAD MEASUREMENT (Renamed: Force Measurement Systems for Forces under the Plantar Surface of the Foot)

RTI Team Personnel: Robert Wallace

Problem:

The orthopedic and sport shoe industries currently are assessing new classes of viscoelastic materials for incorporation into custom orthotic footwear products. These materials in many respects mimic the shock-absorbing characteristics of the calcaneal and metatarsal fat pads found under the heel and ball of the foot. At present, custom footwear providers have no effective procedure for assessing the thickness of the foot's fat pads. An accurate clinical measurement of the thickness of these fat pads is needed to establish the "thickness" that is to be "made up" by prescribed thicknesses of custom shoe insole materials including viscoelastic polymers. The required technology must exhibit a high degree of device and system integration in its basic design and should be fabricated using commonly available large-scale integration processing techniques employed in microelectronics manufacturing. The required technology should be a largely stand-alone microprocessor-based system and should provide for commonly available serial or serial/parallel data communications with other common medical microcomputer systems such as IBM-PC compatible computers.

One of the major indicators of quality of life for the aged or the handicapped is personal locomotive independence. The continued functioning of the natural human walking apparatus is a key sustaining factor in human health. The cost of treating walking or locomotive disorders across all sectors and ages of the American population has not been documented, but evidence is overwhelming that enhanced preventive measures would generate substantial net savings in heath care costs. In addition, greater and more enduring periods of patient comfort and satisfaction with orthopedic aids further reduces the demand and, ultimately, the cost of acute orthopedic care.

At present, a wide range of foot problems combined with poorly fitted footwear contribute to a large body of pathological foot conditions. Foot problems such as insensitivity and hypersensitivity can ultimately lead to ulcers and even more severe

conditions requiring partial or full amputation. Many costs of the current inadequate foot health care system are hidden to the point that no real statistics exist on the substantial costs of poor foot health. What is known is the obvious savings that can accrue from a reduction in the quantity and severity of otherwise avoidable orthopedic foot surgery. A critical enabling technology for better foot health management is the calcaneal/metatarsal fat pad measurement system. The impact of such a system would be significant.

Status

The RTI team is currently working with NASA Langley to identify sources of cofunding and possible manufacturers.

COLOR FILM PRESERVATION AND ENHANCEMENT

RTI Team Personnel: John G. Cleland

Source of Problem: MSFC Space Sciences Laboratory and TU Office

Problem

The concept of NASA technology being applied to color film preservation originated with an MSFC patent in 1981 (U.S. Patent 4,287,152; Inventors: R. B. Thurber and C. M. Rhodes, Huntsville, AL). The primary objective was the improved preservation of high-speed transparencies, such as Ektachrome film (as opposed to, for example, Kodachrome and Cibachrome films). The approach taken retards dye fading during archival storage by placing the film in a sealed, opaque vault, introducing a dry, pressurized inert gas, and sealing the vault. The interior is kept at low relative humidity.

RTI Team followups, especially with Eastman Kodak labs in Rochester, NY, have indicated that recent improvement of Ektachrome paper has greatly increased its longevity. Contacts with the Smithsonian Institution and the National Archives, as well as Kodak, led to the conclusion that inert gas film preservation is a limited market, **but** that other NASA technology developments could make an important impact in film preservation and enhancement. All contacts made mentioned NASA digital imaging techniques and NASA research, development, and applications in image enhancement. Some contacts were also interested in new cold storage techniques, especially high-energy efficiency refrigeration systems. What is needed is NASA technical expert identification of current film preservation/enhancement approaches (especially as applicable to photographic and motion picture film, documents, and archives).

Principals

Mr. Tim Vitale, Smithsonian Institute
Ken Harris, Doug Thurman, Roger Gord, and Richard Youso, National Archives
Dr. Charles Bard and Dr. Robert Tuit, Eastman
Mssrs. Ishmail Akbay and John Richardson, MSFC TU Office

Status

Kodak conducted market studies in inert gas preservation and found that the market consisted of only a few museums. Kodak experts are particularly interested in NASA techniques for cold storage and image enhancement. At the same time, the National Archives has established a Digital Image Applications group that would like to discuss these techniques with NASA experts. NASA has applied techniques related to photographic preservation and enhancement, especially in remote sensing, applying three-color image decoding and encoding. The JSC has a cold storage freezer for film preservation. It has been documented[1] that NASA, in development of high-speed optical read/write storage, is testing a prototype with data-transfer rates in the 100-MB/s range with a capacity of 10^{13} bytes on 12-inch optical disks. NASA is also testing a proprietary coating that distorts when struck by a high-intensity laser beam and remains distorted until electrically erased, making the optical disk a true read/write device. The RTI Team is attempting to find more information on these research efforts. Eastman Kodak, the National Archives, and the Smithsonian Institute are all interested in cooperative projects with NASA.

Reference

1. *Aerospace America*, December 1984.

DIGITAL HEARING AID

RTI Team Personnel: Reed Barnett

Problem

Hearing impairment is a widespread problem. In the elderly alone, 60 percent (approximately 15 million individuals) are considered hard of hearing. Additional millions of younger people are affected due to illness, birth defects, or damage. Conventional analog hearing devices, though producing improvement in many individuals, are inadequate for most and unusable for many. Washington University has been working on a digital hearing aid for several years under sponsorship of the VA.

NASA Technology

NASA's advances in areas such as digital circuitry, microelectronics, miniaturization, and systems development are applicable. KSC's experience in developing a digital Operational Intercom System and work at GSFC and JPL in Very Large Scale Integratec (VLSI) circuits are directly applicable. At the suggestion of the RTI Technology Applications Team, KSC engineers met with researchers at Washington University to discuss the utilization of NASA technology to develop a miniaturized digital hearing aid. Washington University requested KSC's assistance in advancing the development of the digital hearing aid.

Principals

Tom Hammond, KSC
Dick Davis, KSC
Dr. M. Jhabvala, GSFC
Dr. Maynard Engebretzen, Washington University
3M Corporation

Cost to NASA

Funding of $50K in FY 1986 and 1987 was allocated.

Status

A 6-month feasibility study conducted by Washington University to assess overall technical feasibility, identify specific technology applications, and develop a long-range project plan. This study was completed in March 1987.

At the request of KSC, RTI contacted Dr. Jhabvala at GSFC to identify NASA VLSI technology needed in the project. A joint effort is underway with a (JPL) VLSI facility.

The 3M Corporation has agreed to collaborate in the development program with the goal of commercializing the Digital Hearing Aid. RTI worked with Dr. Engebretson, the 3M Corporation, KSC, and GSFC to develop a project plan that delineates each organization's responsibilities and commitments in the project.

IMAGE ENHANCEMENT FOR LOW-VISION REHABILITATION

RTI Team Personnel: Dan Winfield

Problem

In 1977, there were in excess of 1.4 million persons in this country with severe visual impairment of which the vast majority have some remaining functional vision. These persons are said to be "partially sighted" or to have "low vision." A NASA/ Wilmer Eye Institute workshop highlighted the fact that currently available vision aids for this population are, on the whole, woefully inadequate. Most of these are purely optical devices with inherent limitations in both capability and acceptability. Although some closed circuit television systems are used to provide magnification and, in some cases, contrast enhancement, the full range of possibilities for image enhancement have not yet been explored.

The Wilmer Eye Institute has asked NASA to explore the capabilities of image processing as it relates to the provision of enhanced images to low-vision individuals. Developments needed to fully investigate this concept include versatile image processing software to facilitate evaluation of various algorithms, real-time processing capability, display devices with adequate resolution and contrast, and, ultimately, the capability for miniaturization of the components.

NASA Technology

Applicable technologies have been identified at several NASA Centers and four RTOPs have been submitted. The concept and status of each of these is discussed separately in the following pages. RTI and NASA-Ames organized a 2-day NASA TU Low Vision Planning Meeting, held at NASA-Ames, February 5-6, 1987. The objectives of this meeting were to encourage communication, collaboration, and technology sharing among the four NASA Centers and respective clinical partners. Each Center presented the scope, objectives, and technical approach of their projects and common technology areas were identified. Professionals from the National Eye Institute, Smith-Kettlewell Eye Institute, and VA-Palo Alto were present to provide feedback to the project leaders. An integrated program plan (summarized in the attached flowchart) was prepared and submitted by RTI to NASA Headquarters.

IMAGE ENHANCEMENT FOR LOW-VISION REHABILITATION: IMAGE PROCESSING

National Space Technology Laboratory (NSTL)

There is currently poor understanding of how low-vision persons, or even normally sighted persons, use their vision in the performance of various daily tasks. There is only limited understanding of the relationship between the nature of visual impairment and functional performance, and this is an area of current, active research supported by the National Institutes of Health (NIH), among others. In addition, research on this subject is limited by the research equipment used to assess visual performance during performance of real tasks.

It is unrealistic to expect development of a dramatically improved vision aid based on electro-optical image processing technologies until these other questions can be answered by researchers in this field. Thus, it is the primary objective of the project to provide a first generation image processing machine to permit this visual research to progress at a vastly enhanced rate. It is expected that this system will evolve, and, based on research knowledge generated, improved hardware capabilities, and continued funding, a portable, affordable low-vision aid can be developed.

The components of the proposed system are:

- Hardware:
  - Host computer (Possibly IBM-PC AT)
  - Pipeline processor (frame-rate image processor such as PIPE from NBS or PIFEX from JPL)
  - Spatial Remapper (frame-rate pixel remapping such as Programmable Remapper from JSC or CONMAP from NBS)
  - (In Phase 4) head-mounted display with eyetracking (such as under development at ARC)

- Software:
  - Master task operating system
  - Application-specific modules.

NSTL will serve as lead NASA Center in this project and will establish final specifications, design and create software, and perform system integration. **Wilmer Eye Institute** will provide medical guidance regarding requirements and specifications, will establish a designated laboratory with required support personnel to maintain the system, and will conduct all clinical testing. NSTL will ask **ARC** to develop an eyetracker-controlled head-mounted display based on work from their Virtual Environmental Display System and related technology transfer project.

Funding requirements are:

- Software and system integration—4,240 man-hours
- Hardware—$200,000 to $300,000

IMAGE ENHANCEMENT FOR LOW-VISION REHABILITATION: HELMET DISPLAY

Ames Research Center (ARC)

The objective of this project is to provide a diagnostic tool and a reading aid for low-vision individuals. A single device to serve both functions will be developed based upon the helmet-mounted display system being developed by ARC. The main hardware modification required will be the integration of an eyetracker for controlling the display. Eyetracking is a planned addition to the ARC display to provide such capabilities as high-resolution area-of-interest displays or to measure eye convergence and present the plane of best focus (Z-axis).

By employing an eyetracker, this device will be able to yoke the display to eye position, thus repositioning the displayed image to maintain a fixed correspondence to the observer's retina. This capability will then be employed in two principal applications:

- **Field Testing**: Accuracy of current visual field testing is limited by the patient's ability to maintain steady fixation. With the proposed device, this requirement is eliminated and the device becomes a much more valuable diagnostic tool as well as a prognostic tool in predicting visual performance capacity.

- **Reading Trainer**: Current visual rehabilitation techniques for patients with central field loss attempt to train the patient to fixate eccentrically. With the proposed device, the rehabilitation instructor can control the location of the text relative to the scotoma and thus quickly demonstrate the advantage of eccentric viewing. Also, this will facilitate determination of the optimal location of text for each patient.

Status

Specifications for the proposed device were established and hardware procured.

The design has been implemented first with binocular eye tracking and a single bench-top display. Following testing of this first system, a stereoscopic display will be developed and integrated. **ARC** is developing all hardware and display control software, while the **Pennsylvania College of Optometry** will provide medical guidance, develop application-specific software, and test the system in the clinical setting.

Required funding for the project will total $261K, of which NASA TU has provided $80K in FY87 funds.

IMAGE ENHANCEMENT FOR LOW-VISION REHABILITATION: SPATIAL REMAPPER

Johnson Space Center (JSC)

JSC has invented a programmable remapper designed to perform real-time spatial remapping between input and output video images. Specifications have been completed and hardware is under development at Texas Instruments. Project has been co-funded to date by U.S. Army MICOM and NASA TU.

The objective of this project is to employ the remapper to test the applicability of spatial remapping to low-vision rehabilitation. This will include determining optimum and minimally satisfactory two-dimensional spatial remappings as well as optimum and minimum frame rates. Various remapping algorithms will be tested on both normal and low-vision subjects in various daily living tasks: reading, navigation, and face recognition. Conducted in parallel to studies involving the use of the remapper in space, machine vision, automation, missile guidance, and other military applications, these studies will seek a "least common denominator" design of the hardware so that it can be implemented in a portable, affordable device.

JSC will manage this effort and will be evaluating the remapper in a variety of projected applications. JSC will redesign remapper based on field tests, and, with sufficient funding, contract to have it reduced to a VLSI version. The **University of Houston** will provide medical guidance regarding specifications and will conduct all low-vision field tests. JSC will ask **ARC** to provide an eyetracker-controlled head-mounted display. JSC will interface to the remapper. JSC will collaborate with **NSTL** on development and testing of effective algorithms.

Funding consists of (required):

FY87 - $150K
FY88 - $300K
FY89 - $850K
FY90 - $450K

Sources consist of:

	NASA TU	US Army	Others
FY85		$170K	Sell desirability of real-time remapping to military expecting they will ned to bear brunt of VLSI costs. Market technology for industrial R&D funding for military, machine vision, low-vision applications.
FY86		$170K	
FY87	$40K	$ 90K	
	$30K		
FY88	$50K	$250K?	
FY89	$50K	$800K?	
FY90	$50K	$400K?	

IMAGE ENHANCEMENT FOR LOW-VISION REHABILITATION: LOW-VISION AID

Jet Propulsion Laboratory (JPL)

The objective of this project is to develop a portable, inexpensive (< $2,000) low-vision aid with the following features:

- Process images in real-time
- Custom VLSI chips for image enhancement
- Initially in the form of a portable CCTV system
- Ultimately in a head-mounted camera/display version.

This device would consist of:

- CCD camera
- PIFEX convolvers and D/A interface
- Display (CRT or LCD)
- Battery-powered CMOS circuitry
- Programmability through master computer (e.g., microVAX).

The specific technical approach to image enhancement involves measurement of the individuals' transfer function via contrast sensitivity testing and computing the reciprocal. This will be used to develop an optimum compensation filter that will be convolved with the images in real-time. Preliminary research has yielded a 20-percent reduction in magnification required for word recognition. Target is 40-percent reduction.

JPL proposes a 3-year project designed to result in a prototype portable low-vision aid. The effort will lead to specification of optimum compensation filters that will be implemented in VLSI chips. However, in addition, JPL is interested in evaluating the use of an entire PIFEX module to allow greater flexibility in implementing image enhancement algorithms. This is complementary to the objectives of NSTL.

JPL will lead this effort both in terms of hardware/software development and in conducting clinical tests to define optimum enhancement algorithms. The **Center for the Partially Sighted** and the **USC Doheny Eye Institute** will provide facilities and patients for the clinical evaluations.

Funding consists of (required):

FY87 - $135K
FY88 - $139K
FY89 - $139K

Sources consist of:

- FY86 - NASA TU, $50K
- FY87-89 - NASA TU, National Eye Institute, NIDRR, Office of Naval Research

IMPACT-RESISTANT MATERIALS FOR VEHICLE ARMOR

RTI Team Personnel: John G. Cleland
Source of Problem: Maloney Armor Corporation, Schaumburg, IL

Problem

Armored limousines for government personnel, dignitaries, and other VIPs must meet U.S. Department of State criteria or specification by users. Two considerations have caused limousine armorers to seek support from NASA technology: (1) protection criteria are becoming more stringent and (2) competition to find lighter, stronger, and more reliable materials is increasing. Typical performance criteria are for the automobile armor to totally defeat five 7.62-mm caliber rounds, maximum/minimum velocities of 2,825/2,775 ft/s, at 10 ft from target impact, fired within a 3-in. diameter circle. A typical approach to increasing protection in these vehicles (which usually cost from $250,000 to $500,000) has been to add more high-hardness steel, e.g., up to 2,500 lb more vehicle weight at $3 to $5/lb. The armorer has set, as a maximum, adding 14 lb/ft^2 to meet new specifications and considers that 10 lb/ft^2 would be a very good solution. The armor must be configurable to the contour of an automobile and attachable to the existing support. An additional 1/2-in. thickness would be acceptable. Kevlar has not been adopted as yet because of questions about loss of integrity with time under relatively severe environmental conditions (e.g., 140 °F and high humidity). Combined ceramics and Kevlar, incorporating a woven/rubberized matrix, have been examined preliminarily. The armorer is also interested in transparent windshields and side windows that will meet the same impact-resistance criteria.

NASA Technology

The first response to the RTI problem statement came from the JPL (January 1986). Maloney President Jim Centner has been put in touch with Dr. Tom Walters at JPL. The armorer with whom the RTI Team is consulting appears to have some preference for a metal/elastomer laminate solution. However, any NASA technology will be considered. The RTI Team has had preliminary discussions with materials experts at LaRC, ARC, and LeRC. A recent discussion by the Team with Mr. Len Haslin at ARC indicated that his recent development of a "Delta material" polymer composite laminate structure may offer a solution. NASA

composite research for turbine blade improvement does not appear to be directly applicable. Ceramics backed with Kevlar, alumina-silicon carbides, and boron-aluminum composites have been discussed with NASA, but no particular solutions have been identified. The RTI Team will investigate micrometeoroid protection studies done by JPL personnel.

Principals

Mr. Tom Walters, JPL
Mr. John Buckley, LaRC
Mr. Howard Goldstein, ARC
Mr. Don Petrasek, LeRC
TU Officers at each Center
Mr. Jim Centner, Maloney Armor Corporation
Mr. Len Haslin, ARC

Cost to NASA

Estimate $50k for feasibility study.

Status

Contacts will be maintained with limousine armorers, and the RTI Team will wait for Center responses to this problem statement. If identification of NASA technology and progress toward an applications engineering project warrants, the RTI Team will investigate the possibility of additional support from the Department of Defense and other Federal agencies, including the State Department.

INFRARED ROBOTIC CONTROL LINK

RTI Personnel: Robert Wallace

Source of Problem: Factory Automation Industry (Wilton Industries Inc.)

Problem (Technology Requirement)

State-of-the-art real-time factory floor communications is seen as a critical technology for sustaining American worldwide industrial competitiveness. Most current factory floor communication systems are based on fixed networks of cables that can severely constrain manufacturing flexibility at times. Many of the latest advances in manufacturing flexibility are predicated on more autonomous, intelligent machines and workstations requiring only occasional human supervision. A large proportion of these new factory floor subsystems require both voice and data communications capabilities. Many in turn also require both wireless and multiple channel communications links. These new intelligent factory floor subsystems are largely based on the most popular microprocessors and microcomputers available today such as the IBM-PC or VME-based systems. A technology void exists today wherein microcomputer-based intelligent subsystems can communicate only with other systems over hard cable networks. A multichannel wireless infrared communications capability is needed for the most common factory floor microcomputers such as the industrialized IBM-PC and VMEbus or Multibus II based industrialized microcomputer systems. The technology needed includes not only infrared (IR) transceiver networks but IR-compatible intelligent modems or I/O boards, fiber optic and/or electrical cabling systems, and a full set of selectable communications protocols that reflect the range of computer-to-computer communications protocols found on today's American factory floor.

NASA Technology

NASA JSC has extensive systems engineering and design capability in Tracking and Communications. This capability will be employed to develop commercially viable wireless communications products for both NASA and factory floor automation needs. Wireless IR communications technology is currently scheduled for testing on board the Space Shuttle in the summer of

1988. This generation of technology will be enhanced for American factory automation uses. Related software technology includes Ada communications driver software being developed for Space Station network communications.

Status

A NASA JSC TU RTOP was prepared and submitted for a three-phase project. The Phase 1 effort began in May 1987. Phase 2 of the project is divided into subphases a and b to begin in November 1987 and January 1988, respectively. Preliminary indications are that Phase 2a will get underway at JSC largely on schedule with $75K of funding. Project developments anticipated in the near-term include:

- Acquisition of a Votan voice I/O computer card
- Demonstration of a single 64-kilobit communications link
- Initial development of a full duplex I/R channel
- Incorporation of Ada communications software driver.

Phase 2b will be redirected slightly to emphasize the use of Ada communications driver software. Phase 2b is anticipated to represent the beginning of formal coordination of joint developments with the AdaNet Project and initial project cofunding by groups within the Department of Defense.

INTEGRATED SYSTEM FOR THE MANAGEMENT OF WANDERING BEHAVIOR IN MEMORY-IMPAIRED OLDER PERSONS

RTI Team Personnel: Doris Rouse, Dan Winfield, Larry Trachtman

Source of Problem: NIA, AoA, VA, NIDRR

Problem

As part of a joint effort by five Federal agencies to develop devices that could benefit older persons, a formalized Interagency Agreement between NASA and the above agencies has called for the development of a device to assist the memory-impaired elderly and, specifically, those persons suffering from wandering behavior. The Technology Applications Team received funding for and completed Phase I, Needs Assessment and Feasibility Analysis, for this device. The five agencies have decided to support Phase II, Device Design and Hardware Development, and Phase III, Evaluation.

Wandering behavior, frequently observed in older persons suffering from Alzheimer's disease and other dementing illnesses, is a serious problem with possible life-threatening consequences for individuals living at home or in an institution. Although wandering is often purposeful and goal-oriented for the older person, the confused and disoriented individual who wanders into a busy street or inclement weather could risk serious injury or death. In addition, wandering behavior is disruptive and extremely stressful for family caregivers. The stress and safety factors associated with wandering are often major factors in the decision to institutionalize an elderly family member.

Current systems have not proven their effectiveness, nor are they perceived as the best solution to the problem. The cost to monitor one doorway can range from $800 to $4,500. In addition, the alarms used in these devices can distress the wanderer as well as disrupt the staff and other patients. One study of 170 nursing homes found that only 5 percent of the institutions were using this type of system. For the home setting, no device is available that will allow the wanderer freedom of movement and warn the caregiver in the event of danger.

NASA Technology

The NASA JSC has proposed to incorporate state-of-the-art tracking techniques into a modular system design that will provide continuous locating of the wanderer and provide warning signals to both caregiver and wanderer. Among the technologies to be considered in developing the design are: radiofrequency communications, time-of-flight systems, triangulation methods, microwave radar, IR communications, TV systems, and other communications technologies.

Principals

Shayla Davidson, JSC, Houston, TX
Ed Corwin, Cortrex Electronics, San Bernardino, CA

Cost to NASA

	NASA	AoA	NIA	NIDRR	VA	Manufacturer
Phase A Engineering Design	20	20	20	20	20	100
Phase B Prototype Development	40	40	40	40	40	200

Status

The RTI Team met with the principals at JSC, and a project plan for Phase A was developed and initiated. JSC obligated approximately $25K funding to an in-house contractor to begin tradeoff assessments. RTI subcontracted with Mr. Patrick Donaldson to assess a new commercial system and its status and report to the Interagency Work Group in March 1987. Following evaluation of the system, it was decided to proceed and the final draft of the Statement of Work was prepared. RTI participated as an advisor to the Source Evaluation Committee in two meetings at JSC during July and August 1987. Five proposals from companies were received at JSC, and the contract awarded to Cortrex Electronics. Completion of Phase A is scheduled for March 1987.

Action

RTI will continue its liaison role between JSC, the IAWG, and outside consultants.

INTRACRANIAL PRESSURE MONITOR

RTI Team Personnel: Daniel Winfield

Problem

All current methods for monitoring intracranial pressure (ICP), that is, pressure within the skull, require invasive procedures. These consist of either insertion of an intraventricular catheter or a transcranial bolt instrumented with pressure transducers. Risks associated with these invasive procedures (primarily infection) limit their usefulness in many marginal cases of head trauma and limit the length of time they can be used. A noninvasive method to measure ICP would be an extremely valuable clinical and research tool.

NASA Technology

NASA-developed ultrasonic pulsed phase-locked loop (P^2L^2) technology can be used to make sensitive measurements of variations in sound propagation properties of materials due to environmental influences. Since sound propagation within the skull will vary with ICP, P^2L^2 technology should be capable of detecting changes in ICP.

Principals

Dr. Tom Yost, Langley Research Center, Hampton, VA

Dr. Anthony Marmarou, Department of Neurosurgery, Medical College of Virginia (MCV), Richmond, VA

Cost to NASA

NASA funding has been committed as follows:

	FY84	FY85	FY87	FY88
NASA	$25,000	$59,700	$100,000	$85,000
NIH	--	--	--	--
Industry	--	--	--	--

Status

Concept feasibility has been proven in tests involving a skull filled with a pressurized bladder. Adequate sensitivity with the P^2L^2 technique was demonstrated. Instrumentation for animal studies was completed at LaRC and delivered to MCV in May 1986. LaRC hypothesized that, in addition to developing a correlation to ICP, the instrument may also directly measure the pressure-volume index (PVI), which would provide a direct, noninvasive measure of brain compliance. Tests at MCV confirmed this, and Dr. Marmarou was pleasantly surprised at the accuracy with which PVI was measured noninvasively. Although the PVI is a clinically useful parameter, the hoped-for objective remains actual ICP measurement, which will require further signal processing development.

LaRC has continued theoretical and experimental studies to validate a naive, two-component, acoustic model of the brain. LaRC is developing additional signal processing to attempt to extract actual ICP from the return signal. In addition, a second instrument has been built in preparation for clinical studies. A meeting was held at MCV on May 27 to review status of this project and test results. Although results are very encouraging, a more rigorous analytical model is required to isolate the source of the P^2L^2 measurements to ensure they are directly related to ICP.

Action

LaRC will continue analytical studies. In addition, at the May 27 meeting, it was decided that little is to be gained by studies with unavailable cats, and baboons are inaccessible at this time. Thus plans call for the next series of tests to be conducted in the Intensive Care Unit with clinical patients. These are expected to begin in the 4th Quarter, 1987.

ION EXCHANGE FILM

RTI Team Personnel: John G. Cleland

Problem

Ion removal from water is an important problem in environmental control and industrial wastewater treatment. An example is the removal of potentially toxic metal ions from process wastewaters in the electroplating industry. Improved ion exchange or ion removal materials are constantly being sought that have particular selectivity, high flux rate, and other advantages associated with innovative process schemes.

Principals

Drs. Wa. en Philipp and Charles May, LeRC, CWC Industries, Inc. (Cleveland, OH), and RAI, Inc., NY. Additional polymer research/manufacturing organization(s) to be identified following demonstration of initial feasibility by CWC.

NASA Technology

A radiation cross-linked, polyacrylic-acid-based film was developed by Drs. Philipp and May at LeRC in conjunction with the REDOX battery program. This film has demonstrated excellent success in selectivity for removing cations from water.

Cost to NASA

LeRC cofunding estimates from the proposed project plan are as follows:

Participants	Phase O	Phase 1
NASA	$80,000	$40,000
Developer cofund	$40,000	$20,000

Status

The RTI Team formulated a project plan to be completed by the LeRC TU Office. The Team also completed a sample Statement of Qualifications, Dear Colleague letter, and attachments for the Dear Colleague letter to be sent to six possible participants with whom the Team has been in contact and who have expressed considerable interest in pursuing this technology transfer. The project plan was approved and funding forwarded to the LeRC TU Office. The Team identified RAI, Inc., as a possible manufacturer of polymer films. LeRC negotiated a purchase order with RAI to produce films for preliminary evaluation, and RAI processed 100 ft^2 of film for evaluation. The films continue to be evaluated by CWC, with mixed results to date. Further testing is planned.

Action

Continue assistance to LeRC to broaden commercial possibilities.

MACHINE VISION OPTICAL CORRELATOR USING DEFORMABLE MIRROR SPATIAL LIGHT MODULATOR

RTI Team Personnel: Robert Wallace

Problem

Traditional machine vision techniques require software-intensive mathematical mapping of the visual scene for extraction of useful information from the computer representation of the scene. When this image processing is done using a serial Von-Neumann-based algorithm, processing requires so much time that the vision capability is not practical for real-time applications. Practical real-time machine vision requires a large degree of parallelism in the processing of the optical scene. A technique is needed that will provide a machine vision capability with some of the natural parallel image processing characteristics of the human vision system.

NASA Technology

Automated techniques for payload object detection, tracking, and ranging have been under development in the Tracking and Communications Division at NASA's JSC. The most advanced work in this area has been based on an optical information processing technique. This technique involves matching optical Fourier transforms of a reference image against an external scene as seen by a solid-state camera device. As the technique uses camera optical lenses, it is inherently parallel in the two dimensions of the image plane.

Central to parallel optical scene analysis is a two-dimensional (2-D) X, Y addressable spatial light modulator (SLM). When incorporated into a complete optical correlator package, a reflective 2-D SLM such as the Texas Instruments deformable mirror SLM is capable of rapidly matching 128 x 128 pixel arrays. The rapid target recognition capability of such 2-D optical processing arrays supports a number of industrial and military machine vision applications.

Principals

Dr. Richard Juday, NASA's JSC
Mr. Jeff Sampsell, Texas Instruments Central Research Laboratories, Dallas, TX
Dr. Don Gregory, U.S. Army Missile Command, Huntsville, AL

Cost to NASA

	Funding, 10^3				
	FY85	**FY86**	**FY87**	**FY88**	**FY89**
NASA TU	165	115	35	50	25
NASA OAST	200	--	--	100	125
Industry	--	445	450	400	400
U.S. Army MICOM	170	170	170	100	75

Status

Line-addressed deformable mirror SLMs providing 128 x 128 elements have been fabricated at Texas Instruments Central Research Laboratories. The fabricated devices are working, and the electronic driving circuit boards have been integrated into the optical correlator breadboard. The complete optical correlator package was delivered to NASA-Johnson in May 1987.

A series of papers describing the analytical basis for the operation of the optical correlator have been submitted to several technical conferences. A meeting was held with John Neff of the Defense Advanced Research Program Agency to explore future project activities. Two optical correlator-related Small Business Innovative Research (SBIR) projects are under way. Phase II SBIR projects and new Phase I SBIR projects are being considered as vehicles to achieve additional commercial product forms of the optical correlator package.

Action

RTI will meet with JSC principals to explore the potential forms of commercially packaged versions of the correlator system. One intermediate correlator package format will be an aircraft-based version for rapid detection and recognition of vehicles located on the ground. The same system will be used to perform machine vision tests in support of proximity operations for orbital maneuvering vehicles, STS applications, and Space Station robotic vision tasks. A mechanism to disseminate these technical developments to industry will be planned.

MULTICHANNEL FLOW CYTOMETRY

RTI Team Personnel: Dan Winfield

Problem (Technology Requirement)

The technical difficulties in performing multichannel flow cytometry limit its usefulness in both clinical and laboratory settings. Technical improvements needed include improved signal processing for multichannel analysis of optical emission spectra, reductions in complexity, size, and numbers of optical sensors, simplification of sample preparation, and expert system software. The American Cancer Society-Florida Division expressed this need to NASA-KSC and RTI. RTI conducted further background research and located ongoing research and development work on these problems within NASA JSC.

At present, single-channel flow cytometry can measure DNA or other constituents nicely. However, with the advent of monoclonal antibodies used to tag specific antigens, multichannel fluorescence is needed to look at concurrent changes. Because separate fluors are required, this requires separate excitation and emission wavelengths. Thus, each additional fluor requires an additional laser, PMT, and ADC. The system quickly becomes cumbersome and evaluation difficult due to the overlapping emission spectra.

A new technology is needed to allow multispectral analysis of an emission spectra that may include overlapping spectra from several (up to five or six) fluorescent dyes. In addition, it would be desirable to use a single excitation light source rather than multiple lasers. Underlying all aspects is the need for the system to be user friendly in all aspects so that it may be used routinely in clinical and laboratory settings by staff with limited training in optical physics. This includes minimizing the complexity of setup and operation and simplifying sample preparation and may include the use of expert systems technology to assist operation as well as interpretation of data.

NASA Technology

Dr. Gerald Taylor of NASA-JSC has contracted with the Los Alamos National Laboratory to investigate the feasibility of designing and developing a Flow Cytometer for Space Station. Among the requirements that JSC will specify for the system are:

- User (i.e., astronaut) friendly
- Reduce size to $\leq 1\ m^3$
- Minimum of five, preferably eight, channels
- Safe, low-power light source
- Rugged but lightweight
- Efficient handling of wastes and expendables.
- Modularity to facilitate performance upgrades.

Because these requirements are comparable to those for an earth-based clinical system, Dr. Taylor agreed to include a set of terrestrial specifications in his directions to Los Alamos for the feasibility study and suggested a workshop as a mechanism to initiate this collaboration. Such a workshop offers the unique opportunity to input terrestrial requirements early in the design phase of a space-based instrument.

Principals

Dr. Gerald Taylor, NASA JSC Life Sciences
Dr. Tudor Buican, Los Alamos National Laboratory
Dr. David Robinson, American Cancer Society (ACS)

Funding

	Funding (10^3)			
	FY87	**FY88**	**FY89**	**FY90**
NASA TU	15	60	100	40
NASA Life Sciences	5	100	280	180
American Cancer Society	10	30	60	50
Industry	--	--	--	100

Status

The Advanced Flow Cytometry Workshop was conducted by RTI in Los Alamos, NM, June 1-3, 1987. Participants included clinical researchers, flow cytometry technologists, biomedical space researchers, industry representatives, and NASA scientists and program managers. The meeting (1) confirmed the technical feasibility of building an instrument to meet NASA's requirements, (2) recommended this technology be combined in some form with imaging capability, and (3) confirmed that the technological developments will be of great benefit to Earth-based applications.

Seven categories of applications of such an advanced cytometry workstation were delineated and volunteers identified to lead further definition of technical requirements in each of these areas:

Application	Leader(s)
Complete Blood Cell Count	Carl Stewart - Los Alamos National Laboratory
Surface Antigen Characterization	Susan Sharrow - National Cancer Institute Diether Recktenwald - Becton Dickinson
Biological Dosimetry	Zbigniew Darzynkiewicz - Sloan Kettering Ron Jenson - Lawrence Livermore
Pharmacodynamics	Awtar Krishan - University of Miami
Cytoplasmic Immunochemistry	Kenneth Bauer - Northwestern University
Cell Function	Howard Shapiro - Boston
Bioprocessing Quality Control	Paul Todd - BPRC, Philadelphia

Transcription of the recorded proceedings has been completed. In addition, a summary report will be submitted to **Cytometry** for publication. JSC has established this as a formal Life Sciences project as well as a parallel TU project. Funding for FY88-FY90 has been requested. The ACS Scientific Committee, at its August meeting, voted to support this project, and a proposal for ACS action is in preparation.

Action

Secure ACS funding for project. Develop the commercialization strategy.

PASSIVE SENSORS FOR AMBULATORY MONITORING OF FETAL HEART RATE AND FETAL MOVEMENT

RTI Team Personnel: Dan Winfield

Problem (Technology Requirements)

Improved passive sensors, such as microphones and accelerometers, are needed to incorporate into an ambulatory fetal monitoring unit for use in high-risk pregnancies.

Background

Doctors have known for a long time that the rate at which the fetal heart beats and how that rate responds to stresses such as fetal movement are accurate indications of fetal health. Generally, a fetus is felt to be stable if its fetal heart rate (FHR) accelerates in relationship to fetal movement and the FHR automatically varies with time.

Current testing of this type requires stationary ultrasound equipment in the hospital or medical clinic. Such nonambulatory equipment is not satisfactory for use in medical studies seeking to determine the effects of various environmental and behavioral patterns and health patterns experienced or practiced by the mother. What is conceptualized is a wearable monitor that would gather data on fetal heart rate and fetal movements in an ambulatory setting such as the home. This would allow more frequent and more routine evaluation of fetal health and earlier detection of potentially fatal developments in those high-risk pregnancies.

A passive sensor, such as a microphone array, is needed to listen for the fetal heart rate. However, the mother's heartbeat as well as other bodily sounds and environmental sounds are superimposed on the sound of the fetal heartbeat. Recent advances in signal processing technology allow the use of autocorrelation techniques to identify the fetal heart rate from this complex signal. Experiments to date indicate two frequencies that correlate highly with the fetal heart rate--30 hertz and 120 hertz.

In addition to the fetal heart rate, it is necessary to measure fetal movements to correlate variations in fetal heart rate with fetal movement. It is anticipated that an accelerometer of optimum design should provide sufficient sensitivity to make this measurement.

NASA Technology

Acoustics experts at NASA-LaRC propose using PVF_2 film as a piezoelectric sensor for fetal heart sounds and fetal movement. The sensor would be developed in-house at LaRC with signal processing being developed at Old Dominion University.

Principals

Dr. Allan Zuckerwar, NASA-LaRC

Dr. Donald Baker, Ronan, MT

Dr. James Smeltzer, Medical College of Virginia

Status

RTI (Winfield) met with LaRC staff to discuss plans for this project. From this meeting and telephone conversation with Dr. Baker, Hewlett-Packard was identified as a desired commercial participant.

Action

RTI will work with Dr. Baker to secure Hewlett-Packard as a participant. Active project work is planned to begin in January 1988 due to current commitments by LaRC principals.

PROCESS SURFACES FOR CONTINUOUS CASTING OF STEEL

RTI Team Personnel: John G. Cleland

Problem

The American steel industry has lost considerable ground to foreign competition in recent years. Many U.S. steel mills are outdated and technologically behind. The steel industry is attempting to diversify its interests and improve its technology. One important area for the improvement/diversification is continuous casting/continuous formation of billets, which is more efficient and less time- and labor-intensive than the more conventional batch casting. But continuous casting has been well-developed only recently in the United States (Japanese and European companies are already strong in this area), and, to be competitive, U.S. industry must seize on new and improved technology and on better manufacturing approaches.

NASA Technology

The NASA's LeRC has developed high-nickel alloys and composite material that can solve abrasion and thermal stress cracking problem on mold and roller surfaces on continuous casting.

Principals

Mr. Bill Waters, LERC TU Office

Mr. Len Westfall, LeRC

Mr. Lou Lazaretti and Mr. George Wagner, Gladwin-Ohio, Inc. (Gladwin-Ohio has become a subsidiary of Westinghouse, Inc.)

Cost to NASA

Cofunding for the project plan is: NASA $80,000, Gladwin-Ohio $80,000.

Status

The Technology Applications Team assisted LeRC in the preparation of a project plan for submission to NASA Headquarters. The Team arranged meetings between LeRC and Gladwin-Ohio and, through a number of contacts with both, reached a well-defined project plan. The project plan was approved, and the project was initiated at a kickoff meeting at LeRC on July 26, 1985. Small roller testing by Gladwin has indicated that lifetimes may be doubled or increased even further. Larger rollers delivered for testing showed some corrosion problems because of the coating porosity. Debonding of mold sample plates has caused some problem and LeRC is working on a solution.

Action

Review project progress in December 1988.

PROGRAMMABLE AUTOMATIC SHUNT SYSTEM

RTI Team Personnel: Doris Rouse

Problem

Hydrocephalus is an excessive accumulation of fluid within the natural cavities of the brain. As the volume of the fluid continues to expand, it does so at the expense of brain tissue so that the untreated hydrocephalic child may suffer severe physical and mental retardation. Current treatment usually involves the surgical insertion of a shunt to divert CSF to another part of the body. An estimated 50 percent of hydrocephalus patients require at least one reoperation to replace or repair a malfunctioning shunt.[1]

Solution

A CSF control system capable of detection and telemetry of data on the pressure and/or volume of the brain ventricle could prevent most shunt failures and the clinical consequences of increased intracranial pressure resulting from those failures.

NASA Technology

NASA technology in microelectronics; command/telemetry systems; and miniaturized, high-reliability hydraulic control systems could be used to develop an improved CSF control system.

Principals

Mr. Don Friedman, Technology Utilization Officer, Goddard Space Flight Center
Mr. Robert Fischell, Johns Hopkins University, Applied Physics Laboratory, Laurel, MD
Dr. Wen Ko, Case Western Reserve University, Cleveland, OH
Dr. Harold Rekate, Barrow Neurological Institute, Phoenix, AZ

Commercialization Strategy

Mr. Don Friedman and the RTI Team met with two major CSF shunt manufacturers, Heyer Schulte Corporation and Cordis Corporation. Cordis Corporation and American Hospital Supply Corporation participated in the feasibility studies. Cordis was

part of the project team selected for the Engineering Design phase. Recently, a reorganization of the Cordis product development activities has resulted in a decision by Cordis to withdraw from the project. RTI has supported Don Friedman and APL in their efforts to identify another manufacturer.

Status

RTI participated in the first Working Group meeting for the Programmable Automatic Shunt System held in Scottsdale, AZ, January 12-14, 1986. Since that meeting, a reorganization at Cordis Corporation has necessitated that company's withdrawal from the project. A. V. Mueller Corporation in Chicago has been selected as the manufacturer to replace Cordis.

Action

RTI will continue support to GSFC.

Reference

1. Murtagh, F. R., Quencer, R. M., Poole, C. A. Extracranial complications of cerebrospinal fluid shunt function in childhood hydrocephalus. *Am. J. Roentgenol.* 135(4):763-766, October 1980.

ROBOT PERFORMANCE TESTING SYSTEM

RTI Personnel: John G. Cleland

Source of Problem: Robot Analysis Associates (RAA)

Problem

A robot performance test system is needed that would allow evaluation of point-to-point accuracy and repeatability of manipulators. A proposed system would consist of (1) one or more IR emitters located in the robot work envelope to serve as "targets," (2) IR sensor located on the robot arm tool plate, (3) a microprocessor to condition and process signals received from the sensor, and (4) a computer to serve as a hierarchical control for the microprocessor, to analyze data received from the microprocessor, and to drive any desired readout devices. The combination of a target, a sensor, and a microprocessor with output signals directly to a robot controller would permit continuous compensation for drift and other performance errors of the robot.

The system should have the ability to measure xyz deviations from the target centroids with a resolution of $\pm$0.001 inch, at a maximum distance from the target of 0.5 inch. Sensors should respond to target emission at a distance of 2 inches and have the ability to compensate for ambient noise. Velocity should be measurable toward or over a target in the range of 0 to 150 inches/second with an accuracy of $\pm$10 percent.

NASA is particularly requested to provide ideas on the microprocessor, which should have the power to process the three deviation signals, the velocity signal, and, if it can be devised, a target number within a few microseconds. This microprocessor would be located in the robot base and hard-wired to both the robot controller and the computer. It must compute velocity from the rate of polarity change of the sensor differential transformers (time card required). Microprocessors should take a reading on receipt of a signal from the robot controller and signal the controller when the reading has been completed. A host

computer may have to be able to introduce a delay in the reading measurement for controllers that signal ahead of actual dead center. The microprocessor could also delay the reading after receipt until measured velocity reaches zero. The host computer might order the microprocessor to take readings in subgroups of typically five consecutive cycles and then omit readings for the next 15 to 200 cycles. The microprocessor would have to be able to accept such commands.

NASA Technology

Centers pursuing A&R activities, including KSC, JPL, LaRC, MSFC, and ARC, should be able to make direct input to both the microprocessor and total test system designs. Work cell functions relating to a test system are ongoing at KSC, JPL, MSFC, and LaRC.

Principals

Mr. Arthur Brown, RAA

Cost to NASA

Estimated cost of a feasibility study is $90,000, half of which may be obtainable through venture capital.

Status

A problem statement has been completed and is being circulated to several NASA Centers including JPL, LaRC, JSC, and MSFC. Four venture capital firms are being contacted by RAA. The problem is also being discussed by the Technology Applications Team with the National Bureau of Standards (NBS).

Action

Solicit responses from NASA Centers to problem statement. Arrange meeting among RAA, the Technology Applications Team, and NASA microprocessor and sensor experts.

ROTARY REACTOR FOR LATEX PRODUCTION

RTI Team Personnel: John G. Cleland

Source of Problem: NBS; Emulsion Polymers Institute—Lehigh University; MSFC; Dow Chemical Corporation

Problem

Monodisperse particles are currently marketed in the United States by at least four companies, primarily for research and calibration purposes. During Earth-based production of these particles, coagulum formation is a primary problem (i.e., the agitation of the polymerizing particles causes collisions, resulting in flocculation of the particles). NASA-MSFC has sponsored a successful program to produce monodisperse microspheres onboard the Space Shuttle. The objective is to apply technology developed through this program to improved, Earth-based, emulsion polymerization production of latexes, including not only monodisperse particles but also commercial latexes of the types used for paints, paper coatings, carpet backing, foam, and adhesives. At this time, Earth-based commercial emulsion polymerizations are carried out by batch, semicontinuous, or semibatch polymerization. All incorporate the problem of coagulum formation and resulting residual monomer. The question has been raised as to whether or not a rotating reactor can be used to grow monodisperse latex particles and commercial latexes without coagulum. Reactor scaleup must also be addressed if the successes in the small, 100-mL reactors flown on the Space Shuttle are to be duplicated on Earth. A number of markets could be addressed by new low-coagulum latex reactors, including chromatographic separation, calibration standards, medical research, drug dispersion, and a significant percentage of the $100 billion/year chemicals industry.

Principals

D. M. Kornfeld, MSFC

Dr. J. W. Vanderhoff, PTI and EPI

Cost to NASA

The NASA contribution required under the project plan is estimated to be $120,000, with significant laboratory support from NASA-MSFC.

Status

D. M. Kornfeld at MSFC has proposed that emulsion polymerizations be carried out in an Earth-based, horizontally mounted, rotating cylindrical reactor simulating microgravity. A project plan has been completed and forwarded to NASA Headquarters to initiate ε 1-year program to investigate the success of such an approach. This program will be conducted with Particles Technology, Inc. (PTI), and the Emulsion Polymers Institute (EPI) at Lehigh University. The unique reactors will be fabricated and operated to perform a testing and analysis program to demonstrate performance. The potential for commercial application of these reactors will be assessed. PTI will assume responsibility for commercial implementation.

NASA Headquarters has funded the first-phase effort, which is underway. A spinoff resulted when the Bioprocessing and Pharmaceutical Research Center (BPRC) in Philadelphia expressed interest in a rotary reactor for mammalian cell growth. The RTI Team identified a designer and fabricator, and this reactor was developed and delivered. Dr. Jack Sloyer of the BPRC has expressed great satisfaction with this unit.

Action

Continue to provide assistance as requested from MSFC TU Office.

STABILIZED PHOTOGRAPHIC PLATFORM FOR PUBLIC SERVICE HELICOPTERS (PSHs)

RTI Personnel: John G. Cleland

Date of Preparation: March 3, 1985

Source of Problem: Huntington Beach Police Department, Huntington Beach, CA

Problem (Background, Technology Requirements, and Solution Specifications)

A stabilized platform, coupled with a camera, an IR imager, or a low-light television (LLTV) camera can enable police agencies to observe ground activity and gather evidence from a remote, undetected vantage point. Such platforms should reduce torque disturbances caused by vibrations from a helicopter's rotor system to 0.05 to 2 milliradians and make it possible to utilize lenses with long focal lengths. The attachment would be either cabin- or belly-mounted on the helicopter and, ideally, would make it possible to film and observe targets with lenses that can focus on 2-inch letters (license plates) from a 1- to 2-mile distance. Externally mounted pods or obtrusive platforms are to be avoided. Both gyro stabilization and optical correlation/image enhancement should be considered. It may be possible to mount optics on a stabilized platform and remotely mount the camera. An approach of using stabilized mirrors to reduce jitter also needs further investigation. A display of objects under surveillance is desirable at the pilot or copilot station in the PSH. The cost range of a marketable stabilized platform is estimated to be $50,000 to $100,000.

Principals

Mr. Vic Cordell and Mr. Steve Hermann, RECON
Mr. Carl Bouvier and Dr. Tom Walters, JPL

Cost to NASA

First-phase costs are $75k and $50k to RECON, $25k to JPL.

Action

Provide any assistance required to ensure project startup in next quarter.

Status

The Technology Applications Team arranged meetings between NASA Headquarters, JPL, and RECON Research and helped RECON with a project plan. RECON's approach for developing a platform with JPL assistance was accepted and a project initiated. RECON has completed this project through a documented flight test, utilizing two helicopters and equipment provided by 14 different vendors.

The PSH market is estimated to be in the range of 50 to 75 units, although it is obvious that a moderately priced stabilized platform could have a much broader market for aviation and other mobile photography applications. The RTI Team has also discussed with Wright-Patterson Air Force Base (AFB) their program for Forward Looking Infra-Red (FLIR) stabilization. Wright-Patterson AFB indicates interest in combining their objectives with those of NASA technology transfer.

STIRLING ENGINE

RTI Personnel: John G. Cleland

Date of Preparation: August 7, 1985

Source of Problem: Environmental Protection Agency (EPA); DOE; NASA LeRC; U.S. Automobile Manufacturers—GM, Ford, Chrysler; U.S. Air Force

Problem

The automotive industry and other engine manufacturers and users continue to attempt to develop an engine with (1) high fuel efficiency, (2) high reliability and low maintenance, (3) low noise levels, (4) low emission levels, and (5) multifuel operation. The Stirling engine has the potential to meet all these requirements. NASA has been involved with Stirling engine development for a decade, especially through the Automotive Stirling Engine (ASE) project largely funded by the DOE and administered by NASA's LeRC. The problem has been to identify NASA technology contributions to continuing development of the Stirling engine and to establish an Applications Engineering project that could contribute significantly to near-term commercialization of the Stirling engine. The primary requirement is the demonstration in a real-world environment of those technology advances that have been developed in the laboratory under NASA guidance.

Principals

NASA LeRC, U.S. Air Force, Deere & Co., MTI, Purolator-Courier, the American Trucking Association, and the DOE.

Cost to NASA

Costs for the 1-year first phase were $150,000 from NASA TU and $150,000 from the NASA/LeRC Stirling Engine Office. Second-phase costs will be $500,000.

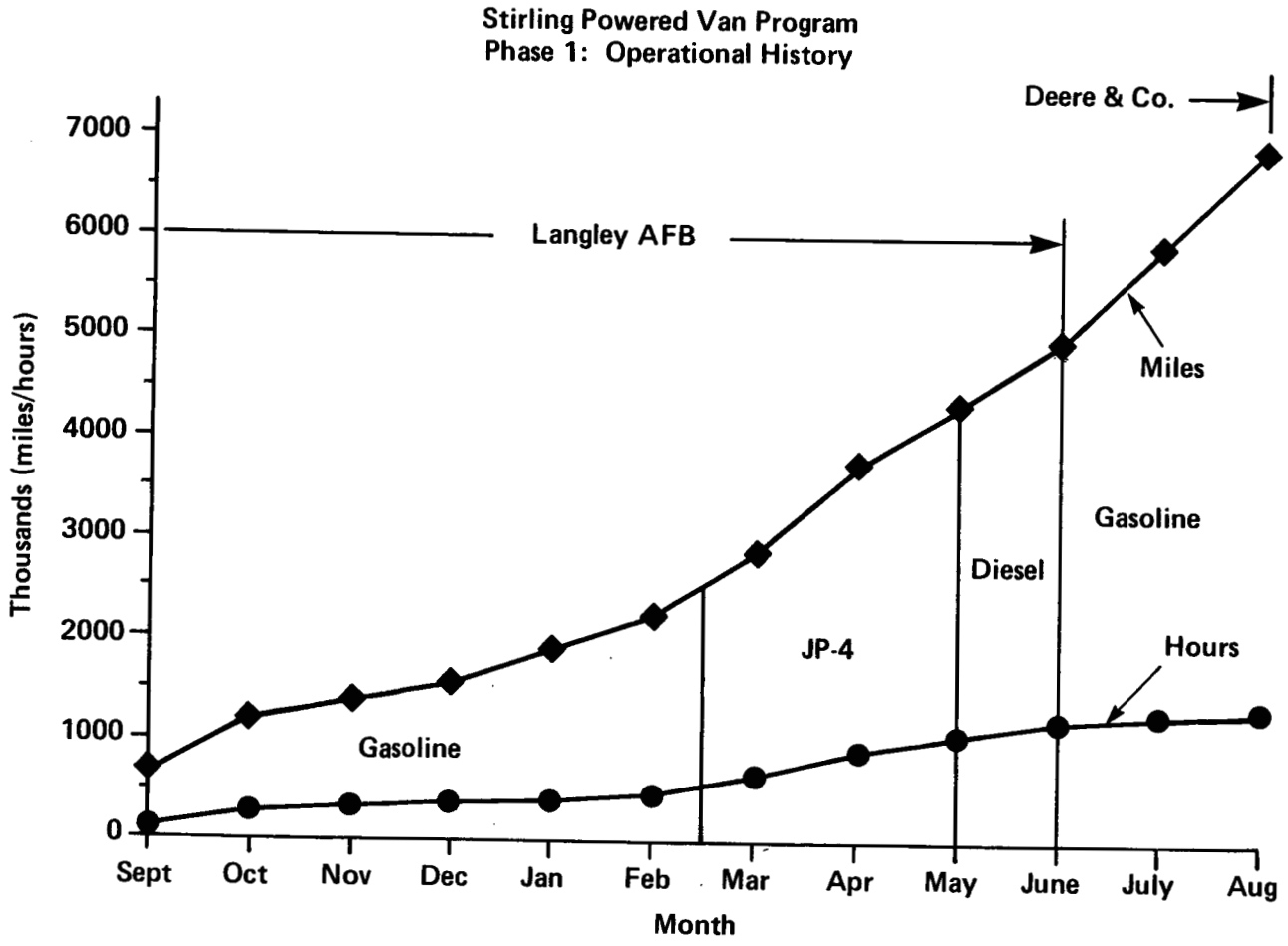
Status

The NASA LeRC has identified those technology transfers that need to be evaluated further or demonstrated in a rigorous test program. These NASA contributions to Stirling engine advancement include low-cost heater heads, analytical codes, a free-piston Stirling engine, solid lubricant coatings (PS2000), filament-wound pressure vessels for hydrogen storage, and continuing developments toward an orbiting Stirling space power system. A project was initiated in FY86 through NASA Headquarters' Office of Commercial Programs. The project is titled "Stirling Powered Van Program" and consists of three phases: The first phase demonstrates a Mod I Stirling engine under mild climate conditions (the engine will be mounted in an Air Force van and tested for at least 1,000 hours of operation at Langley Air Force Base).

Funding was approved by NASA Headquarters, engine testing at MTI was completed, and over 1,000 hours of operation have been completed in an Air Force step van (see figure). Monthly progress reports are received by NASA Headquarters and the Technology Applications Team. A videotape entitled "An Alternative Power Plant—The Stirling Engine" is available on loan from LeRC.

Action

Continue to provide assistance as requested by the LeRC TU Office.


Stirling Powered Van Program
Phase 1: Operational History
Deere & Co.
Langley AFB
Miles
Hours
Gasoline
Diesel
JP-4
Gasoline
Thousands (miles/hours)
7000
6000
5000
4000
3000
2000
1000
0
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
June
July
Aug
Month

SYSTEMS AUTONOMY APPLIED TO ELECTRIC UTILITIES

RTI Team Personnel: Reed Barnett

Problem

The complex, technical problems associated with effectively and efficiently monitoring the status of, and controlling modern, power-generating plants, especially nuclear plants, has been underscored since the accident at Three-Mile Island and more recently at Chernobyl. But the ability to interpret properly and to utilize the extensive sensor data available at a nuclear power plant is of great value in dealing with lesser emergencies as well as improved efficiency for day-to-day plant operation. The search for solutions to these problems is spearheaded by the Electric Power Research Institute (EPRI) and private power companies.

NASA Technology

NASA has an ongoing program for developing artificial intelligence core technology in the general field of systems automony, including: fault/recognition and diagnosis, fault recovery, task planning/replanning, and intelligence operator interfaces. KSC is developing a new generation Launch Processing System using many of these core technologies as well as other knowledge-based systems technologies developed at KSC. Two of these systems, LES (Liquid Oxygen Expert System) and KATE (Knowledge-based Automatic Test Equipment) are directly applicable to this program of monitoring and controlling power-generating plants. EPRI has recognized this and is actively working with KSC to apply these technologies on behalf of the power industry.

Principals

Tom Hammond, KSC
Tom Davis, KSC
Joe Naser, EPRI

Cost to NASA

A preliminary project plan was prepared showing funding as follows:

	1987	1988	1989	1990	TOTAL
NASA	184	236	176	0	596
EPRI	234	401	409	148	1,192
TOTAL	418	637	585	148	1,788

Status

Funding has been approved by NASA Headquarters. A grant has been negotiated with EPRI to encompass a 3-year program.

ULTRASOUND DIAGNOSIS OF BURN DEPTH

RTI Team Personnel: Daniel Winfield

Problem

Approximately 2 million Americans suffer serious burns each year, and 200 to 300 thousand of these people require hospital treatment. Among those hospitalized, 70,000 receive intensive care and 10,000 to 12,000 patients die from their injuries. The cost of intensive care exceeds $300 million per year. The traditional treatment of burn victims is to allow natural debridement, sloughing of necrotic tissue, to occur and then to close the resulting open wounds with skin grafts. Unfortunately, the weeks required for spontaneous sloughing often result in infection and sepsis; indeed, the major cause of death in burn victims is bacterial infection. Modern treatment, therefore, is based on early recognition and removal of necrotic tissue to reduce infection and hasten healing. This surgical or chemical debridement depends upon accurate burn depth information for optimal results. Current methods for burn depth determination are inaccurate, cumbersome, or both.

Solution

Ultrasound may be used to map precisely and conveniently the depths of the interface between viable and necrotic tissue in burn injuries. Preliminary studies in pigs demonstrate a good correlation between depths of burn measured by pulse-echo ultrasound and by histological techniques.

NASA Technology

Advanced ultrasonic technology developed at LaRC for the characterization of materials is directly applicable to this project.

Principals

Dr. John H. Cantrell, Jr., LaRC, Hampton, VA
Dr. Tom Yost, LaRC, Hampton, VA

Col. Basil Pruitt, Jr., M.D., U.S. Army Institute of Surgical Research, Ft. Sam Houston, TX
Dr. Boyd Haynes, Jr., Director, Burn Unit, MCV, Richmond, VA
Advanced Technology Laboratories (ATL), Bellevue, WA

Commercialization Status

In response to RTI Team inquiries, in 1983 Sonometric Systems, Inc., proposed a collaboration with NASA to develop the system and market it. A corporate reorganization of Sonometrics and a reduction of the technical staff in 1984 limited their ability to respond to the technical requirements of the project and they officially indicated that they will not pursue this project. The RTI Team was instrumental in arranging for two additional manufacturers to visit LaRC for discussions, and ATL was chosen for commercialization.

Status

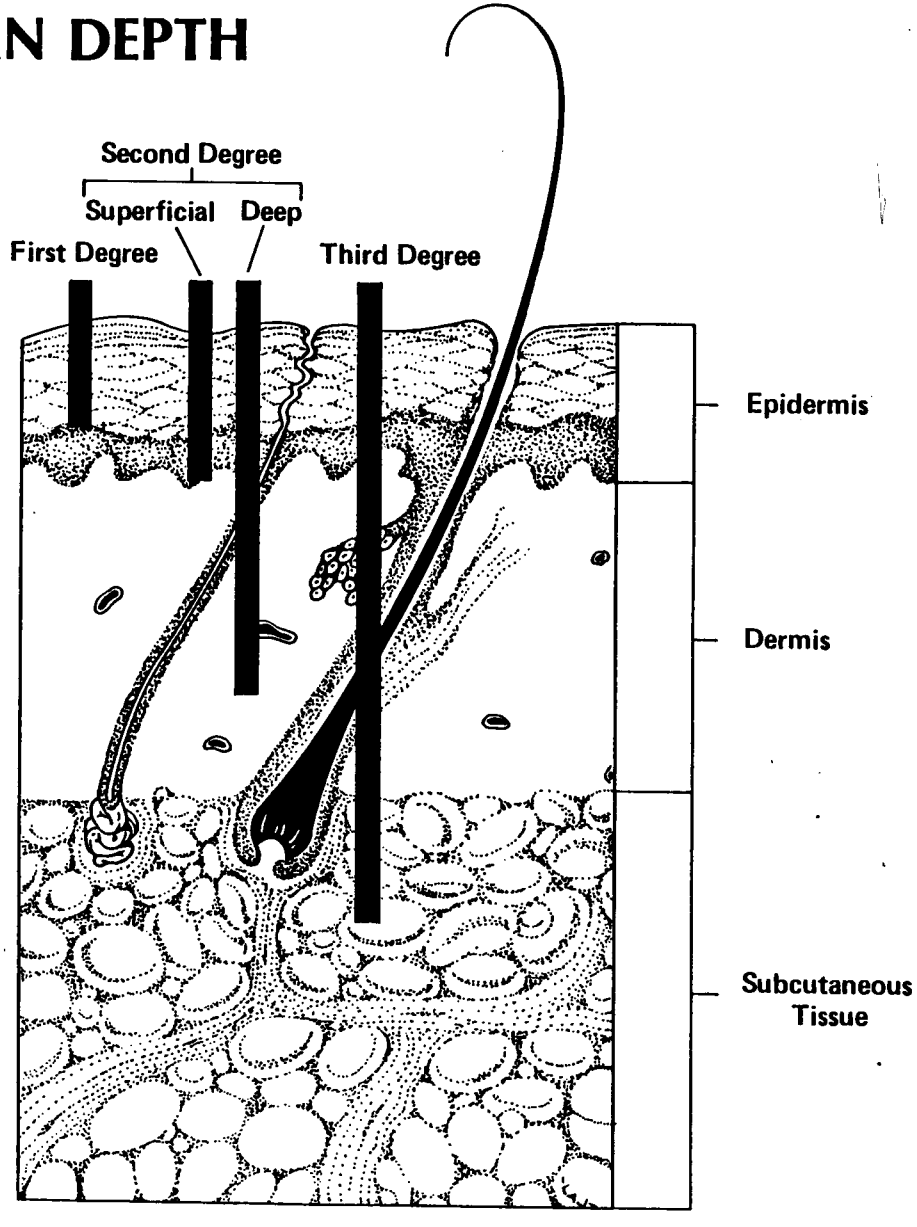
ATL supplied an instrument for the initial preclinical and clinical studies at no charge. In addition, LaRC researchers built a breadboard instrument for initial studies and both instruments have been supplied to MCV. Following development of accurate histological techniques without distortion artifacts, tests were initiated to establish correlations between ultrasound burn depth measurement and histological techniques. Results indicate a 0.93 correlation coefficient, which is felt to be more than adequate to demonstrate clinical efficacy. A second instrument has been delivered to MCV, and a series of clinical trials were completed in the 2nd quarter. Results were very promising. At a project review meeting at MCV on May 27, these results were reviewed and comments provided on a draft report prepared by LaRC.

Action

LaRC will complete a final version of the report and distribute it to MCV and ATL. Through subsequent followup and consultation, NASA will effectively transfer the technology to ATL and MCV for continued development and clinical evaluation.

ULTRASOUND DIAGNOSIS OF BURN DEPTH

- 2 MILLION SERIOUS BURNS EACH YEAR IN U.S.
- NASA TECHNOLOGY IN ULTRASOUND CHARACTERIZATION OF MATERIALS
- U.S. ARMY INSTITUTE OF SURGICAL RESEARCH, FT. SAM HOUSTON, TX
- MEDICAL COLLEGE OF VIRGINIA, RICHMOND, VA
- ADVANCED TECHNOLOGY LABORATORIES, BELLEVUE, WA



Source: *Treatment of Burns.* Yang Chih-chun, Hsu Wei-shia, and Shih Tsi-siang, eds. Springer Verlag, New York, 1982.

URODYNAMIC PRESSURE SENSING CATHETER

RTI Team Personnel: Daniel Winfield

Technology Requirements

Miniature pressure transducer technology is required to provide more accurate, controlled measurements of the pressure profile within the urethra relative to the pressure within the bladder.

The objective of urodynamic diagnostic procedures is to measure the pressure profile within the urethra relative to the bladder pressure under a variety of conditions, particularly during exertion (coughs, body movements, etc.). A pressure-sensing catheter containing two pressure transducers is inserted through the urethra into the bladder so that one pressure sensor lies in the bladder and the second at the top of the urethra. The catheter is then withdrawn at a controlled rate so that a graph of the pressure versus urethral length is obtained. The bladder pressure is then subtracted to obtain the effective urethral closing pressure profile.

A method is needed to measure the urethral pressure or closing force throughout its length simultaneously. The pressure transducers must measure pressures in the range of 0 to 200 cm/$H_2$0 (0 to 7.0 psi) with an accuracy of $\pm$2 cm/$H_2$0 ($\pm$0.07 psi). The optimal design would be able to measure closing force within the urethra from all directions, 360°, and throughout its length, 3.0 cm. If a continuous pressure sensor down the length is not possible, incremental measurements with a resolution of 3 to 5 mm would be acceptable.

Solution

NASA-Langley engineers have proposed a technique to include at least four, possibly up to six, sphincter-closing force measurements simultaneously. Also, a unique fiber optic pressure transducer will be used for the bladder pressure measurement.

Principals

Dr. Andrew Fantl, MCV
Dr. Harlon Holmes, NASA-Langley
Dr. Terry Hadebaugh, NIA

Cost to NASA

Dr. Fantl is currently funded by NIA to study urodynamic pressure measurements in stress incontinence. NASA has provided funding of $35,000 in FY86 and $25,000 in FY87 to support prototype development in-house.

Commercialization Strategy

NASA engineers have expressed preference to complete initial prototype development before pursuing commercialization. RTI has conducted preliminary discussions with Medical Measurements, Inc., Browne Corporation, and Dantec.

Status

After an initial meeting between Langley researchers and Dr. Fantl, it was concluded that NASA expertise in strain gauge and fiber optic pressure measurement techniques offered the potential for solution of some of the problems in urodynamic pressure measurement. NASA-Langley submitted an RTOP that has been funded. Fabrication and assembly drawings were completed, and signal conditioning electronics have been selected. Initial prototypes were found to be too stiff and did not eliminate bending stress from the pressure stress measurement. A second generation sensor assembly employs bellows between sensing areas to eliminate the effect of bending on the strain measurement. The sensor assembly has been incorporated into a 0.125-in. diameter catheter with medically approved latex coating. A working prototype was reviewed with Dr. Fantl in December 1986. Further improvements in the stress measurement were required.

NASA LaRC developed a third-generation prototype with an improved, custom strain-gauge assembly, a dual lumen catheter, and a silicon elastomer coating. This design was reviewed with Dr. Fantl and should be delivered in the first quarter of FY88.

Action

Following initiation of clinical evaluation, RTI will begin commercialization efforts.

VERY HIGH-SPEED MACHINE AXES

RTI Personnel: Robert Wallace

Problem

A revolutionary new design is needed to provide a vast increase in the speed of the work handling axes of certain classes of metal cutting machine tools. Typical of these classes of machine tools are centerless grinders and NC punch presses. Innovative redesign of these types of machine tools is needed to provide workpiece traverse rates of up to 3,000 inches per minute (ipm) and machine table accelerations of 3 to 5 Gs. The dimensional upper limit of the envelope for workpieces to be machined with this system is 4 ft x 8 ft x 1.5 ft and a weight of 1,500 lb. The corresponding work envelope for the actual cutting tool would be on the order of 5 ft x 9 ft x 2 ft.

NASA Technology

NASA expertise in high-speed vibration test stand technology and digital power factor control can be used to optimally design new generations of linear induction motor-based machine sides. NASA optics and high-speed interferometry technology can support fast, accurate electro-optic feedback control of machine slide position and motion. NASA computer modeling and analysis of velocity and acceleration profiles for mass driver systems can be used to refine linear induction motor designs. NASA electromechanical technology such as vibration test stands and flywheels offer potential for energy storage and recovery through electromechanical braking through flywheel spinup. Even more promising are recent NASA MSFC contributions to high-temperature superconducting materials that would be natural candidates for high-speed metal working machine applications.

Status

A TU Project Plan for an FY88 new start was submitted for this problem from NASA Marshall Space Flight Center. Support for the project has weakened at NASA Marshall, but interest has developed at NASA Lewis.

Action

Mr. Robert Wallace of the RTI Team will rework the Problem Statement Package and route it to Mr. Dan Soltis of NASA Lewis as well as other NASA Centers.

7.0 TRAVEL

October 8-9, 1986	Dr. John Cleland met with Grumman Aero, ILC, and with Joe Kosmo, JSC, for a project planning meeting in Frederica, DL.
October 11-15, 1986	Dr. Cleland visited NASA-JPL and met with Walters, TUO, Nancy Leon (JPL), T. Becjzy (JPL), W. Shoeber (JPL), R. Gilbert (NASA Headquarters), C. Bouvier, and Los Angeles and Orange County transit authorities. Discussed bus transit technology, PHS stable platforms, A&R, environmental systems, RIM Tech (Andy Patterson).
October 14, 1986	Larry Trachtman and Dan Winfield met with an executive planning group at Moss Rehabilitation Hospital (MRH) in Philadelphia, PA, to discuss rehabilitation needs identified by researchers at MRH.
October 15, 1986	Dan Winfield and Dr. Doris Rouse traveled to Washington, DC, for an IAWG Meeting. Status of the Wanderer Notification and Low Vision projects was reviewed.
October 19-20, 1986	Robert Wallace presented the objectives of the NASA/NIHR joint program for CAD/CAM for Custom Orthopedic Shoes to the Technical Conference of Footwear Industries of America (FIA) in St. Louis.
October 23-24, 1986	Dr. Rouse traveled to Houston to present the NASA TU program to Harvard Hill, President, and the board of directors of Houston Partners, a national venture capital firm, with Dean Glenn, NASA JSC TU Officer. Dr. Rouse also met with Dr. Walter Marker to prepare a draft project plan for the Wanderer Management project.

October 31-November 4, 1986	Robert Wallace attended the Annual Conference of the American Prescription Footwear Association in San Francisco. He presented the project plan for the NASA/NIHR joint program for CAD/CAM for Custom Orthopedic Shoes.
November 11-12, 1986	Dr. Rouse traveled to JSC to assist Dr. Walter Marker in the preparation of project plans for the Wanderer Management project and to review TU projects with Dean Glenn, TU Officer at JSC.
November 12, 1986	Robert Wallace traveled to LaRC, Hampton, VA, for a kickoff meeting of the University of North Carolina Department of Radiology Footwear Project efforts under NASA/VA funding.
November 12, 1986	Dan Winfield traveled to Washington, DC, to participate in a meeting at NASA Headquarters. Several presentations were made by several agencies interested in work related to Dr. Richard Juday's programmable remapper.
November 13, 1986	Dr. Rouse and Dean Glenn presented the NASA TU program to Mike Barbour, President, and other management of Surgimedics Corporation in Houston.
November 18, 1986	RTI consultant Reed Barnett participated in a planning meeting for the heat pipes demonstration project at Bob's Candies in Albany, GA.
November 20-21, 1986	Dr. Rouse made a presentation on the NASA TU program and the status of the Wanderer Management project at the National Gerontological Society of America meeting in Chicago.
November 26, 1986	Robert Wallace participated in a Washington, DC, meeting at VA Headquarters where he presented the status of the VA/NASA Langley Footwear Project effort.

December 10, 1986	Dr. James N. Brown, Jr., and Dr. Cleland made a presentation on the NASA TU program to AT&T management and technical staff at the Burlington Research Facility.
December 17, 1986	Dr. Rouse, Dan Winfield, and Larry Trachtman met with Dr. David Gray, Director of the National Institute on Disability and Rehabilitation Research, and Mr. Ray Whitten, NASA Headquarters, to discuss opportunities for RTI to participate in the transfer and commercialization of rehabilitation technology.
December 17, 1986	Larry Trachtman met with Dennis LaBuda, Director of the Institute on Lifetime Learning, AARP, in Washington, to discuss new project opportunities in technology and aging.
December 18, 1986	Dan Winfield traveled to Bethesda, MD, to review Low Vision Program with Dr. Constance Atwell, National Eye Institute, and to Baltimore, MD, to review plans for the NSTL-Wilmer Low Vision project with Wilmer Eye Institute Staff.
December 18-19, 1986	Robert Wallace traveled to Crystal Corporation in Minneapolis, MN, to outline a problem statement for a next generation Flexible Manufacturing Cell (FMC) Controller for automating clusters of machine tools and robots under the guidance of a human cell operator.
December 18, 1986	Dr. Rouse met with NASA Headquarters staff to discuss the RTI Application Team's collaborative activities with the Indianapolis Industrial Application Center.
January 8-9, 1987	Dr. Cleland traveled to NASA LaRC in Hampton, VA, to meet with Arnold Engineering representatives, TU Officers and NASA wind tunnel and mechanics experts on testing of the Arnold Oscillating Power Generator. A joint endeavor with LaRC and Arnold is planned.

January 9, 1987	Stephen Lehrman, Dr. Rouse, and William Meade traveled to National Bureau of Standards in Gaithersburg, MD for a meeting with Dr. Robert Hocken and Dr. Tylor Estler. Discussed application of large part metrology to the design of a coordinate measuring machine for case and nozzle parts of the Space Shuttle solid rocket booster.
January 13-14, 1987	Dr. Cleland and Dr. Brown traveled to Harrisburg, PA. Cleland and Brown, along with representatives from the Pittsburgh IAC, presented the TU program to two groups at AMP. Followup contacts were planned and have been carried out.
January 19-23, 1987	Dr. Cleland traveled to Jet Propulsion Laboratory, Pasadena, CA, to conduct a Commercial Users Panel at JPL Space Telerobotics Workshop. Organized and chaired panel. Summary results to be published in workshop proceedings.
January 21-23, 1987	Dr. Rouse participated in the Outreach Executive Committee meeting held at Kennedy Space Center in Orlando, FL.
February 3, 1987	Dr. Rouse met with Dr. Terry Hambrecht and Dr. Jerry Loeb to discuss technology requirements in neural prostheses.
February 3-6, 1987	Dan Winfield conducted a NASA TU Low-Vision Planning Meeting at NASA-ARC. Organizations represented included NASA (ARC, JPL, JSC, NSTL), Wilmer Eye Institute, Penn, College of Optometry, National Eye Institute, Smith-Kettlewell Eye Institute, VA-Palo Alto, and University of Houston.
February 5, 1987	Dr. Rouse participated in a meeting of the marketing subcommittee of the Outreach Executive Committee in Washington, DC.

February 9-10, 1987	Dr. Rouse made a presentation on the NASA Technology Utilization program to the Director, Dr. Ed Cohen, and staff of the New Jersey Commission on Science and Technology.
February 10-11, 1987	Larry Trachtman participated in a NASA TUNS (Technology Utilization Network System) Users Working Group meeting at NASA Goddard Space Flight Center, Greenbelt, MD.
February 10, 1987	Dr. Rouse met with John Samos and Frank Farmer at NASA Langley Research Center in Hampton, VA, to discuss project plans. Dr. Rouse also met with Mr. Paul Brockman to discuss possible transfer activities with Virginia's Center for Innovative Technology.
February 13, 1987	Dan Winfield attended a Bladder Monitor Project Review at NASA-LaRC with staff from the Association for Retarded Citizens.
February 18-20, 1987	Dan Winfield met with staff from NASA-KSC and the American Cancer Society in Orlando to review 19 submitted problem areas and develop recommended action items for these.
February 19-20, 1987	Dr. Cleland and Stephen Lehrman traveled to LaRC for meetings with Dan Soltis (LeRC TUO), Walter Smith (Die Cast Dies), Mario Pohly and Curtis Pohly (Superior Die Casting Corp.), and Dennis Sobol (Rex Buckeye). Discussed problems with pressure die casting of aluminum.
February 24-25, 1987	Dr. Brown made a presentation on the NASA Technology Utilization Program to AT&T engineering staff in Princeton, NJ.

February 25-26, 1987	Dr. Cleland and consultant William Meade traveled to Green Bay and Mannitowac, WI, meetings with Ingersoll-Rand and Autographics Digitrol to discuss water jet cutting. Nozzle design for improved efficiency was defined as a first-priority problem to be addressed by NASA.
March 3, 1987	Dr. Rouse and RTI consultant, Patrick Donaldson, met with the Interagency Group in Technology and Aging to review Mr. Donaldson's assessment of the Total Alert Corporation's wanderer management system.
March 10-11, 1987	Dr. Cleland attended AIAA conference on automation in space in Crystal City, VA. Met with Ken Sebok, Perry Offshore Inc., and Ray Gilbert, NASA Headquarters, about applications projects transferring NASA robotics expert systems to undersea operations.
March 18-20, 1987	Dr. Rouse participated in a meeting of the Outreach Executive committee at Johnson Space Center in Houston, TX. Dr. Rouse also met with TU Officer Dean Glenn and researchers Penny Saunders and Joseph Praether.
March 23, 1987	Dr. Cleland traveled to NASA LaRC, Hampton, VA, to meet with TU Office staff and Les Rose, AMP Inc., representatives Brad Oldenberg and Frank Koblitz, and NASA materials experts Dr. Terry St. Clair and Mr. Bob Baucom. Several problem areas were discussed with followup meetings and discussions planned.
March 24-25, 1987	Dan Winfield attended a Planning Session on Telecommunications and Aging, sponsored by The Markle Foundation, held at Wye Woods, MD.

March 24-26, 1987	Stephen Lehrman and Dave Holmes (FBI) traveled to NSTL for a meeting on Composites Materials Container for Transportation of Explosive Devices. Lehrman also met with Bob Barlow (NSTL TUO), Charles Whitehurst (NSTL ERL), and Doug Rickman (NSTL ERL) to discuss an RTOP for Development of an Information Analysis System for Characterizing the Texas A&M Sonar.
April 2, 1987	Dan Winfield and Dr. Rouse attended the Technology and Aging Work Group Meeting in Bethesda, MD.
April 3, 1987	Dr. Cleland and Stephen Lehrman attended a presentation at LaRC on opportunities for the commercial use of space. Topics discussed included Gas-Permeable Materials, CVD Characterization Facility, Control of Flexible Structures, Automation and Robotics, and NDE.
April 3, 1987	Dr. Rouse participated in a meeting of the National Forum on Technology and Aging in Washington, DC.
April 22-24, 1987	Dan Winfield traveled to JSC to assist the TUO in preparation of project implementation plans for new starts and continuing projects.
April 29, 1987	Dan Winfield traveled to LaRC to develop manufacturer selection plans for Pulmonary Dysfunction Assessment and Fetal Heart Monitoring Projects.
April 30, 1987	Dan Winfield met with executive staff at Lifeline Systems, Inc., Watertown, MA, to discuss the Wanderer Notification Project and upcoming RFP.
May 1, 1987	Visit to Institute of Textile Technology (Dr. Neil Cahill and Staff) to present TU program and discuss potential application project areas (e.g., sensors, expert systems). Followup items detailed Technology Applications Team information and arrangement of ITT meeting with KSC.

May 5-7, 1987	Dr. Rouse attended the Federal Laboratory consortium meeting in Lexington, KY.
May 27, 1987	Dan Winfield met with Dr. Marmarou (MCV) and Drs. Cantrell and Yost (LaRC) in Richmond, VA, to review status of Burn Depth Analysis and Noninvasive ICP projects.
May 27-28, 198	Dr. Rouse attended the Commercial Use of Space (CUS) meeting involving all the Directors of the Center for Commercial Development of Space and the CUS representatives at the Field Center.
May 29, 1987	Dr. Rouse participated in a meeting in Washington of the Interagency Group on Technology and Aging to review status and plans for the wanderer device project.
May 31 - June 3, 1987	Dan Winfield conducted the Advanced Flow Cytometry Workshop in Los Alamos, NM.
June 10, 1987	Dr. Rouse attended a NASA Langley review of Technology Utilization projects in Hampton, VA.
June 12, 1987	Dr. Cleland attended project planning meetings with LaRC TUO, NASA Headquarters (Gilbert), LaRC technical experts (Dr. St. Clair, Michael Wood) and HTS, Inc. (Dr. Milton Evans).
June 16, 1987	Dr. Cleland attended presentations at MSFC of ongoing and proposed applications projects. Attendance by TU Office, RTI, MSFC Director of Science and Engineering, and Ray Gilbert, NASA Headquarters TU.
June 17-18, 1987	Dr. Rouse participated in the NASA/Boeing Commercial Use of Space Orientation workshop held in Washington.

June 26, 1987	Dr. Rouse met in Washington with NASA Headquarters staff and Boeing to discuss coordination of industry outreach.
July 6-8, 1987	Dr. Rouse traveled to Johnson Space Center to serve as an advisor to the Source Evaluation Committee for the Interagency Locator System for Wanderers.
July 9, 1987	Stephen Lehrman and Bob Barlow, Harold Moffitt, and Bob Walker (all NSTL) met with Major Tom Ward at the U.S. Army Hazardous Device School, Redstone Arsenal, Huntsville, AL. The purpose of the meeting was to view steel containment vessels and discuss design parameters for the Composite Materials Container for Transportation of Explosive Devices.
July 10, 1987	Stephen Lehrman and Bob Barlow, Harold Moffitt, and Bob Walker (all NSTL) met with Eugene McKannan, Deputy Director, Materials and Process Laboratory, MSFC. The purpose of the meeting was to discuss MSFC capabilities to fabricate prototype Composite Materials Containers for Transportation of Explosive Devices.
July 13-14, 1987	Dr. Rouse participated in a meeting sponsored by the National Institute of Disability and Rehabilitation Research to develop possible models for improved public and private sector collaboration in the development of rehabilitation devices.
July 15, 1987	Dr. Rouse met with Henry Clarks and Ray Whitten to discuss status of applications engineering projects and Application Team activities.
July 27, 1987	Dr. Rouse participated in a meeting of the National Forum on Technology and Aging in Washington, DC.

July 28, 1987	Stephen Lehrman and Dean Glenn (JSC) met with industry representatives of the Clear Lake Area Economic Development Foundation in Houston, TX. The purpose of the meeting was to discuss Outreach of NASA JSC technology to the petrochemical industry.
July 28-30, 1987	Dr. Rouse participated in a meeting of the NASA Code I Executive Outreach Committee meeting in Huntsville, AL.
July 29, 1987	Stephen Lehrman and Dean Glenn (JSC) made a joint presentation on the NASA Technology Utilization Program to Lockheed Engineering and Management Services Company in Houston, TX.
August 4-5, 1987	All members of the RTI Applications Team traveled to Washington to provide a Program Review for NASA Headquarters personnel.
August 4-5, 1987	Larry Trachtman met in Washington, DC, with Dr. David Grey, Director of the National Institute of Disability and Rehabilitation Research, and Evan Hensley of ILC Dover to evaluate the ILC Cool Vest on Dr. Grey, who is himself a quadriplegic.
August 5, 1987	Stephen Lehrman met with Robert Quigley and David Holmes of the FBI Bomb Data Center in Washington, DC. The purpose of the meeting was to brief the FBI on the status of the Composite Materials Container for Transportation of Explosive Devices.
August 12-13, 1987	Dr. Rouse traveled to Johnson Space Center to serve as an advisor to the Source Evaluation Committee for the Interagency project to develop a Locator for Wanderers.

August 13, 1987	Larry Trachtman attended an organizational meeting of the National Easter Seal Society Technical Advisory Board in Chicago, IL.
August 14, 1987	Dr. Rouse met with Dean Glenn, JSC Technology Utilization Officer, and Jeri Brown to discuss the UNISTIK vehicle project and the infrared physiological data system.
August 27-28, 1987	Dan Winfield traveled to Orlando to make a presentation of project status to the NASA/American Cancer Society Scientific Committee.
September 1-3, 1987	Dr. Cleland attended a meeting of the High Temperature Superconductivity Working Group. At the request of Code I, he presented Technology Utilizations and programs. Dr. Cleland also met with TUO and technical experts to discuss projects.
September 23, 1987	Stephen Lehrman and Forrest Parker (NERAC) made a joint presentation to the engineering department at AT&T—Winston Salem on the NASA Technology Utilization Program.
September 29, 1987	Dr. Rouse met with NASA Headquarters staff to discuss Application Team activities.
September 29, 1987	Dan Winfield met with Dan Woodard and Thora Halsted of NASA Headquarters in Washington to discuss project plans.
September 29-30, 1987	Larry Trachtman met in Washington, DC, with Gallaudet Research Institute, the United Cerebral Palsy Association, and the National Rehabilitation Hospital to discuss possible new problem statements.
September 30, 1987	Dan Winfield met with representatives from NSTL and Wilmer Eye Institute in Baltimore to assist in preparing a detailed project plan for the "Image Enhancement for Low Vision" Project.

APPENDIX A

INDUSTRY ASSOCIATIONS, UNIVERSITIES, AND FEDERAL AGENCIES PARTICIPATING IN RTI TEAM ACTIVITIES DURING CURRENT CONTRACT

INDUSTRY

Advanced Tech. Labs
Albany International
AMP
Analogic, Inc.
Analytics, Inc.
Andran Corporation
Applied Medical Tech.
Applied Sciences
Arnold Engineering, Inc.
AT&T
Autographic Digitrol
B&K Instruments
Balzars Corporation
Beckman Instruments
Becton Dickinson
Becton Dickinson Monoclonal Center
Beneficial Designs, Inc.
Bethlehem Steel
Biodynamics Corporation
Bob's Candies Company
Boeing Aerospace
Bonneville Scientific, Inc.
Brown Shoe
CAMI Health Care, Inc.
Capsulated Systems, Inc.
Carbonite Corporation
Cardionics
Carolina Power & Light Company
Carrier Corporation
Caterpillar, Inc.
Celanese Chemical Co.
Chrysler Corporation
Cincinnati Milicron
Clinitron, Inc.
Coal Gas, Inc.
Colligan
Composite Consultation Concepts
Coopervision
Cordis Corporation
Corning Glass
Cortrex Electronics
Coulter Electronics
CR Bard
Crystal Corporation

CW Ventures
Dantec
David Clark, Inc.
Davis Shoe Therapeutics
Design Ideas
Designs for Vision
Destech
Die Cast Dies
Digital Analysis Corporation
Digital Signal Corporation
Dimensional Medicine, Inc.
Dinh Company
DOW Chemical Corporation
Du Pont
Eagle Engineering Corporation
Eastman Kodak
Egan Group
Electro Optics Consultants
Engineering Development Lab, Inc.
Entropy Environmentalists
Enviro Systems
Ethicon
Everest & Jennings
Eye Movement Tech.
FLIR Systems
Fluid Controls Division
Forbes and Associates, Inc.
Ford Manufacturing Development Center
Foxboro
G.E. Matsco
G.E. Medical Systems
Garlock Bearings
General Electric
Geoquest International, Inc.
Gladwin-Ohio
Grumman Aerospace
Gulf Coast Breeder Corporation
Halkey-Roberts
Hamilton Company
Hercules, Inc.
Heyer Schulte Corporation
Honeywell Corporation
Houston Venture Partners
HTS, Inc.
IBM Research
ICI Americas, Inc.
ILC Dover, Inc.
IITRI
Ingersoll Rand
Innovative Control Systems
Intec Systems, Inc.
Intergraph Corporation
Intex, Inc.
Invacare Corporation
John Deere
Johns-Manville, Inc.
Johnson & Johnson
Johnson Engineering Corporation
Jones & Vining, Inc.
Kennametal Inc.
Kobe-Midrex
Lifeline Systems
Lord Corporation
Lumex

Maloney Armor Company
Martin Marietta
McDonnell Douglas
Mechanical Tech., Inc.
Medical Engineering Corporation
Membrane Technical & Research
MEMTEK
Mesta Engineering Corporation
Microbot
Microdynamics, Inc.
Microelectronics Center of N.C.
Microwave Association, Inc.
Middlestates Energy Corporation
Midwest Steel
NARCO Bio-Systems, Inc.
National Aluminum Company
Niagara-Mohawk
Nordic Corporation
Northrop
Novatech
Ocutech
Ohmeda
Olin Corporation
Ortho Diagnostic Systems
Pacer Corporation
Pacesetter Systems, Inc.
Parker-Hannifin Corporation
Patient Security Systems
Patterson Enterprises
Pennwalt Corporation
Perry Offshore
Phillip-Crosby Associates, Inc.
Pittsburgh Plate Glass
Plasma Energy, Inc.
Prentke Romich Company
Prime Welding Systems
Purolator-Courier
Q-Dot
RAI, Inc.
Raytheon
RECON Research, Inc.
Reeves Engineering Industries
Rehabilitation Care Consultants
REMIC Corporation
Republic Steel
Rex Buckeye Company
Rexnord, Inc.
RIMTECH
Robotics Analysis Associates
Rockwell International
Rohm & Haas
Safety First, Inc.
Scientific Measurement Systems, Inc.
Secure Care Systems
SEPAREX
Shell Oil Company
Siebe North, Inc.
Siecor
Simula, Inc.
Sonometric Systems, Inc.
Southwest Research Institute
SPAR Aerospace
SPARTA Systems
STC Companies

Superior Die Casting Corporation
Surgimedics
Systems Control Tech.
Techmedica
Technicon Instruments Corporation
Teledyne
Telerobotics, Inc.
Telesensory Systems
Telonix, Inc.
TERTM, Inc.
Texas Instruments
Theradyne Corporation
Thermacor Technology, Inc.
Thermo Electron Corporation
Thomas Built Buses
3 M Corporation
Tracor
Trane
Transalaska Pipeline, Inc.
Triangle R&D
U.S. Shoe Corporation
U.S. Steel
Uniforce, Inc.
Union Carbide
Univ. Tech. Corporation
Varian Corporation
W. H. Gore, Inc.
W. L. Gore Associates, Inc.
Walt Disney Productions
Wanderguard Alarm
Westinghouse Electric Corporation
Wilson Greatbatch, Inc.
Wilton Industries, Inc.
Wood-Ivey Corporation
Wyle Laboratories

AGENCIES AND FEDERAL LABORATORIES

Administration on Aging
Argonne National Laboratories
Department of Energy
Department of the Interior
Department of Transportation
Drug Enforcement Agency
Environmental Protection Agency
Federal Aviation Administration
Federal Bureau of Investigation
Federal Emergency Management Association
Food and Drug Administration
Helium Gas Division; Department of the Interior
Human Engineering Laboratory Aberdeen Proving Ground

Lawrence Livermore National Laboratory
National Archives
National Bureau of Standards
National Cancer Institute
National Eye Institute
National Hansen's Disease Center
National Heart, Lung, and Blood Institute
National Institute of Neurological and Communication Disorders and Stroke
National Institute on Aging
National Institute on Disability and Rehabilitation Research
National Research Council
National Institute of Arthritis, Diabetes, and Kidney Disorders
Naval Research Laboratory
Navy Medical R&D Command
New Jersey Commission on Science and Technology
North Carolina Agency on Aging
Oak Ridge National Laboratories
Pennsylvania Agency on Aging
Savannah River Laboratory
Smithsonian Institute
Solar Energy Research Institute
State of Florida
Strategic Defense Initiative Office
The Lighthouse
U.S. Air Force, Brooks AFB
U.S. Air Force, Tinker AFB
U.S. Army Aeromedical Research Laboratory
U.S. Army Industrial Base Engineering Activity
U.S. Army Institute of Surgical Research
U.S. Army Missile Command
U.S. Coast Guard
U.S. Park Police
Veterans Administration
Wyoming State Legislature

INDUSTRY ASSOCIATIONS, TECHNICAL SOCIETIES, AND RESEARCH CONSORTIA

Aerospace Medical Association
Airborne Law Enforcement Association
American Association of Retired Persons
American Cancer Society
American Gas Association
American Helicopter Society
American Iron and Steel Institute
American National Standards Institute

American Society of Heating, Corporation
Refrigeration and Air Conditioning Engineers
American Society on Aging
ASHBEAMS
ASME
Association for the Advancement of Rehabilitation Tech.
Association of Home Appliance Manufacturers
Association of Retarded Citizens
Aviation Law Enforcement Association
Bureau of Mines
Consortium for Space Automation and Robotics
Electric Power Research Institute
Electronic Industries Association
Electronic Industries Foundation
Electronic Motion Control Association
Federal Laboratory Consortium
Florida Solar Energy Center
Footwear Industries of America
Gerontological Society of America
Health Industry Manufacturers Association
Helicopter Association International
IGT
Institute of Textile Technology
Instrument Society of America
National Academy of Engineering
National Association for Home Care
National Association of Area Agencies on Aging
National Association of Home Builders
National Association of Resident Care Facilities
National Easter Seal Society
National Machine Tool Builders Association
Paralyzed Veterans of America
Prescription Footwear Association
Presidents Commission on Employment of the Handicapped
Rehabilitation Engineering Volunteer Network
Robotics Industries Association
Semiconductor Research Corporation
Society of Exploration Geophysicists
Society of Manufacturing Engineers
Technical Transfer Society
Textile/Clothing Technology
The Scoeity of Die Casting, Inc.
United Cerebral Palsy Association

UNIVERSITIES

Barrow Neurological Institute
Baylor University
Carnegie Mellon University
Case Western Reserve
Denver Research Institute
Duke University
Gallaudet University
Georgia Institute of Technology
Johns Hopkins University—Wilmer Eye Institute
Lehigh University
Los Alamos Laboratories
Louisiana State University
Massachusetts Institute of Technology
Medical College of Virginia
Moss Rehabilitation Center
National Rehabilitation Hospital
North Carolina State University
Northwestern University Prosthetics Research Laboratory
Notre Dame University
Ohio State University
Oklahoma State University
Pennsylvania College of Optometry
Pennsylvania State University
Rice University
Rutgers University
Smith Kettlewell Eye Research Institute
Stanford Children's Hospital
Stanford University
Tennessee Technical Foundation
Texas A&M
University of Virginia
University of Alabama-Huntsville
University of California—San Diego
University of Delaware
University of Florida
University of Georgia
University of Houston
University of Illinois
University of Kentucky
University of Massachusetts
University of Miami
University of Michigan
University of North Carolina/Chapel Hill
University of Oklahoma
University of Oklahoma—McGee Eye Institute
University of Utah
University of Washington
Vanderbilt University
Washington University

APPENDIX B

NASA TECHNOLOGY APPLICATIONS TEAM STAFF AND CONSULTANTS, RESEARCH TRIANGLE INSTITUTE, OCTOBER 1987

APPENDIX B

NASA TECHNOLOGY APPLICATIONS TEAM STAFF, RESEARCH TRIANGLE INSTITUTE, OCTOBER 1987

Staff member	Background	Project Responsibility
	RTI STAFF	
DORIS ROUSE	B.A., CHEMISTRY Ph.D., PHYSIOLOGY Eleven years in NASA Program. Five years' research and management in industry.	Project Director Assignment of project tasks to staff and consultants. Program planning, review for all Team projects.
JOHN CLELAND	B.S., AEROSPACE ENGINEERING Ph.D., MECHANICAL ENGINEERING Three years in NASA Technology Utilization Program. Twelve years' industry and U.S. Army research and management experience in process engineering.	Coordination of manufacturing and industrial projects. Areas of specialization include materials and robotics.
STEPHEN LEHRMAN	B.S., MECHANICAL ENGINEERING M.S., MECHANICAL ENGINEERING Thirteen years' experience in mechanical design and analysis for manufacturing industries.	Coordination of manufacturing and industrial projects. Areas of specialization include machine design, precision engineering, and metrology.

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NASA TECHNOLOGY APPLICATIONS TEAM STAFF, RESEARCH TRIANGLE INSTITUTE, OCTOBER 1987

Staff member	Background	Project Responsibility
ROBERT WALLACE	B.A., ENVIRONMENTAL DESIGN M.S., INDUSTRIAL ENGINEERING Four years in NASA Technology Utilization Program. Eight years' experience in CAD/CAM and automated factory simulation.	Coordination of manufacturing and industrial projects. Area of specialization includes automation and flexible manufacturing systems.
DAN WINFIELD	B.S., ENGINEERING ANALYSIS M.S., BIOMEDICAL ENGINEERING Three years in NASA Technology Utilization Program. Eight years' experience in product development and manufacturing in the medical device industry.	Management of biomedical projects. Areas of specialization include ophthalmology and orthopedics.
LAWRENCE TRACHTMAN	B.S., APPLIED SCIENCES IN ENGINEERING M.S., BIOMEDICAL/REHABILITATION ENGINEERING Two years in NASA Technology Utilization Program. Three years' experience in rehabilitation engineering, product development, and marketing in industry and rehabilitation center.	Coordination of rehabilitation projects. Areas of specialization include rehabilitation, expert systems and technology for the elderly.

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NASA TECHNOLOGY APPLICATIONS TEAM STAFF,
RESEARCH TRIANGLE INSTITUTE, OCTOBER 1987

Staff member	Background	Project Responsibility
	CONSULTANTS	
BERNARD MAGGIN	B.S., AERONAUTICAL ENGINEERING Over 35 years' experience in aerospace and energy engineering. Technical and senior management positions in 28 years with NASA. Three years as consultant to RTI Applications Team.	- Management of Public Safety Helicopter project. - Management of Tilt Rotor project. - Consultation with RTI staff on development of Automation and Robotics projects.
WILLIAM PENLAND	B.S., INDUSTRIAL ENGINEERING M.S., INDUSTRIAL DESIGN Fifteen years' experience as biomedical engineer at National Institutes of Health. Three years as consultant to RTI Applications Team.	- Assisting team members in problem identification with NIH staff. - Identification of appropriate resources in NIH for cooperative NASA/NIH projects. - Consultation for laser angioplasty project.
FRANCESCO IANNETTI	B.S., CHEMICAL ENGINEERING M.S., Ph.D., MATERIALS ENGINEERING	- Assisting Applications Team in preparing NASA Thermal Protection Materials (JSC) and materials problem statements.

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NASA TECHNOLOGY APPLICATIONS TEAM STAFF,
RESEARCH TRIANGLE INSTITUTE, OCTOBER 1987

Staff member	Background	Project Responsibility
REED BARNETT	B.S., AERONAUTICAL ENGINEERING Forty years' experience in NASA, serving 5 of those years as the KSC Technology Utilization Officer. One year as RTI consultant	- Assisting Application Team in coordinating Application projects in the southeastern United States. Providing Applications Team support to KSC TU Office.
AUBREY SMITH	B.S. MECHANICAL ENGINEERING Twenty-five years' experience at NASA in flight hardware programs and management activities. Served 6 years as technology utilization officer at MSFC. Served three years at Jet Propulsion Laboratory.	- Assisting Applications Team in developing strategies for industrial outreach and support to NASA Field Centers in Technology Transfer Projects. ects.
TOM DIXON	B.S. ENGINEERING M.S. CHEMICAL ENGINEERING M.S. AERONAUTICAL ENGINEERING Twenty-five years of experience in industry research and engineering and management positions. Served two years as NASA Deputy Associate Administrator.	- Assisting RTI Team in coordination of Ames Research Center projects and outreach to West Coast industry.

APPENDIX C

RTI TECHNOLOGY APPLICATIONS TEAM PROJECTS BY CENTER

APPENDIX C

RTI APPLICATIONS TEAM PROJECTS BY CENTER

Center	Project
ARC	Helmet Display Reading Aid
	Generic Flexible Manufacturing Cell Controller
	3-D Dimensional Auditory System
	High-Temperature Ceramic Polymer and Fiber
GSFC	Digital Hearing Aid
	Programmable Automatic Shunt System
	Intelligent High Performance Robot Gripper
	High Energy Radiotherapy Imaging
JPL	Image Enhancement for Partially Sighted
	Stabilized Photographic Platform for Public Service Helicopters
	Functional Electrical Stimulation Advanced Development
	Corneal Topography
JSC	Management of Wandering Behavior in Older Persons
	Spatial Remapper for Age-Related Maculopathy
	Hydraulic Control System for Body-Powered Upper Limb Prostheses
	Multichannel Flow Cytometry
	Infrared Robotic Control Link
	Automated Chromosome Analysis System
	Deformable Mirror Robotic Vision System
	Unistik

(continued)

RTI APPLICATIONS TEAM PROJECTS BY CENTER

Center	Project
	Infrared Physiological Data Link
	Noninvasive Central Venous Pressure Measurement Device
KSC	Digital Hearing Aid
	Atmospheric Sciences Field Laboratory
	Heat Pipes and Solar-Assisted Heating and Cooling
	Systems Autonomy Applied to Electric Utilities
	American Cancer Society
	Textile Process Control—Expert System
LaRC	Bladder Volume Sensing
	Intracranial Pressure Monitor
	Ultrasound Diagnosis of Burn Depth
	Urodynamic Pressure Sensing Catheter
	CAD/CAM for Orthopedic Shoes
	Passive Sensors for Ambulatory Monitoring of Fetal Heart Rate and Fetal Movement
	Pulmonary Muscle Fatigue Measurement
	Noninvasive Assessment of Tissue Perfusion
	Hyperthermia Thermometry
	Development, Production, and Marketing of Polyimide Sulfone Materials
LeRC	Ion Exchange Film
	Process Surfaces for Continuous Casting of Steel
	Stirling Engine
	Protective Coatings for Advanced Cutting Materials

(continued)

RTI APPLICATIONS TEAM PROJECTS BY CENTER

Center	Project
	Linear Power Generation for the Arnold Oscillating Cascade Power System
	Methods to Reduce Porosity in Aluminum Die Castings
	Protective Coatings for Aluminum Die Casting Dies
MSFC	Rotary Reactor for Latex Production
	3-D Shape Digitization
	Corneal Topography
	Water Jet Nozzle Design
	Topographic Measurement for Patient Positioning During Radiation Therapy
	Industrial Computed Tomography/Computer-Aided Design Integration
NSTL	Image Enhancement for Partially Sighted
	Composites Materials Container for Transportation of Explosive Devices

APPENDIX D

GLOSSARY

APPENDIX D

A&R	automation and robotics
ACS	Ame can Cancer Society
AI	artificial intelligence
AoA	Administration on Aging
AOPS	Arnold Oscillating Power System
ARAC	Aerospace Research Applications Center
ARC	Ames Research Center
ATAC	Advanced Technology Advisory Committee (NASA)
ATL	Advanced Technology Laboratories
CAD/CAM	computer-aided design/computer-aided manufacture
CMLS	completed multilayer substrate
CPSC	Consumer Product Safety Commission
CT	computed tomography
CVD	chemical vapor deposition
CVP	central venous pressure
DCRF	Die Casting Research Foundation
EMS	emergency medical service
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
FBI	Federal Bureau of Investigation
FFT	Fast Fourier Transform
FHR	fetal heart rate
FLC	Federal Laboratory Consortium
FOCS	fiber-optic chemical sensors
FRCI	fiber-reinforced composites insulation
GC/MS	gas chromatrographs/mass spectrometers
GSFC	Goddard Space Flight Center
HIMA	Health Industry Manufacturers Association
HTS	high-temperature superconductivity
IAC	Industrial Application Center
IAWG	Interagency Work Group
ICP	intracranial pressure
I/O	input/output
IPDL	Infrared Physiological Data Link
IR	infrared
ITT	Institute of Textile Technology
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LaRC	Langley Research Center
LCD	liquid crystal displays
LeRC	Lewis Research Center
MCV	Medical College of Virginia
MSFC	Marshall Space Flight Center

NASA	National Aeronautics and Space Administration
NERAC	New England Research Applications Center
NIA	National Institute on Aging
NIDRR	National Institute on Disability and Rehabilitation Research
NIH	National Institutes of Health
NSTL	National Space Technologies Laboratory
OCP	Office of Commercial Programs
PSHTT	Public Service Helicopter Technology Transfer
PVI	pressure-volume index
RFP	request for proposal
RTI	Research Triangle Institute
RTOP	Research and Technology Operating Plan
SBIR	Small Business Innovative Research
SEM	standard electronic module
SLM	spatial light modulator
TI	Texas Instruments
TPS	thermal protection system
TU	Technology Utilization
TUNS	Technology Utilization Network System
TUO	Technology Utilization Officer
UVA-REC	University of Virginia Rehabilitation Engineering Center
VA	Veterans' Administration
VLSI	very large scale integrated